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Yamazaki et al.

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(54) **MEMS ELEMENT FUSE-LIKE ELECTRICAL CIRCUIT INTERRUPTER**

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(51) **Int. Cl.**
H01H 59/00 (2006.01)
H01H 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01H 59/0009*** (2013.01); ***H01H 1/0036*** (2013.01)

(58) **Field of Classification Search**
CPC H01H 59/0009–1/0036
See application file for complete search history.

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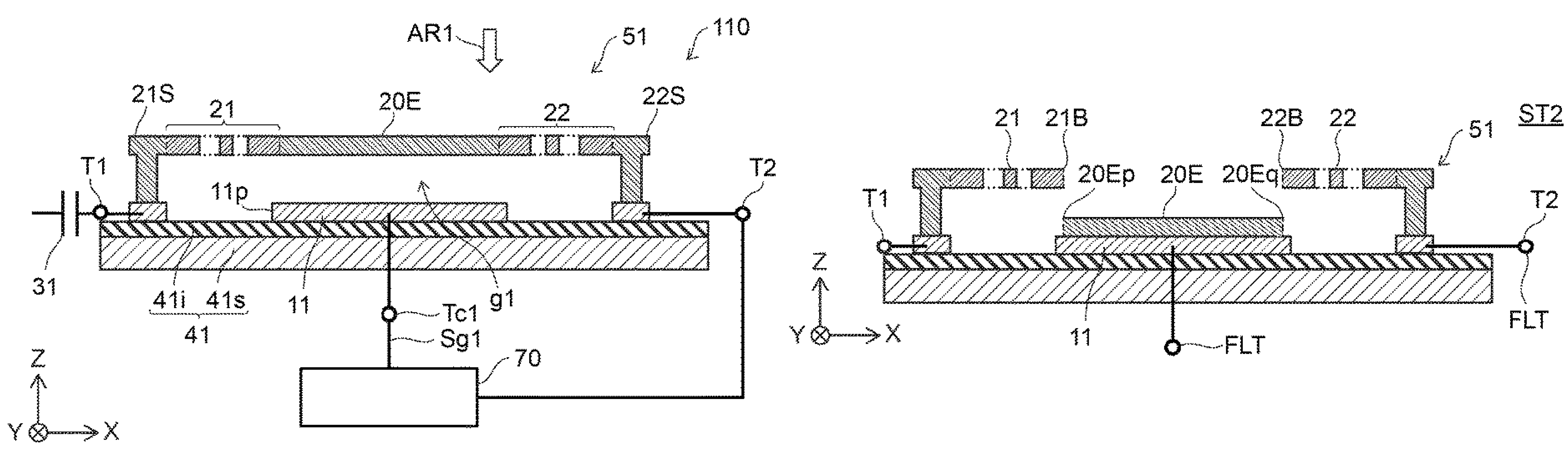
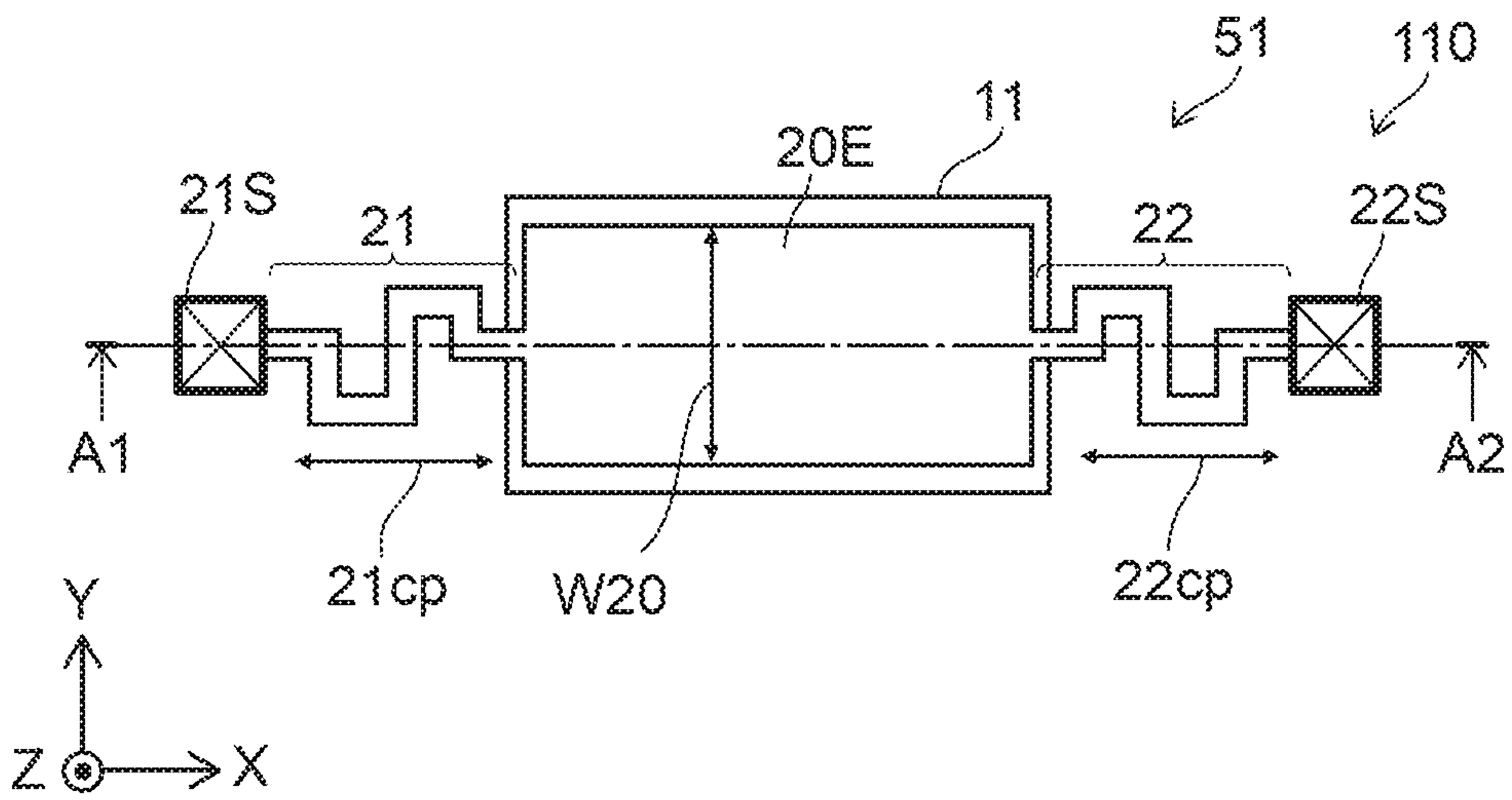
(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner L.L.P.

(57) **ABSTRACT**

According to one embodiment, a MEMS element includes a first member, and an element part. The element part includes a first fixed electrode fixed to the first member, a first movable electrode facing the first fixed electrode, a first conductive member electrically connected to the first movable electrode, and a second conductive member electrically connected to the first movable electrode. The first conductive member and the second conductive member support the first movable electrode to be separated from the first fixed electrode in a first state before a first electrical signal is applied between the second conductive member and the first fixed electrode. The first conductive member and the second conductive member are in a broken state in a second state after the first electrical signal is applied between the second conductive member and the first fixed electrode.

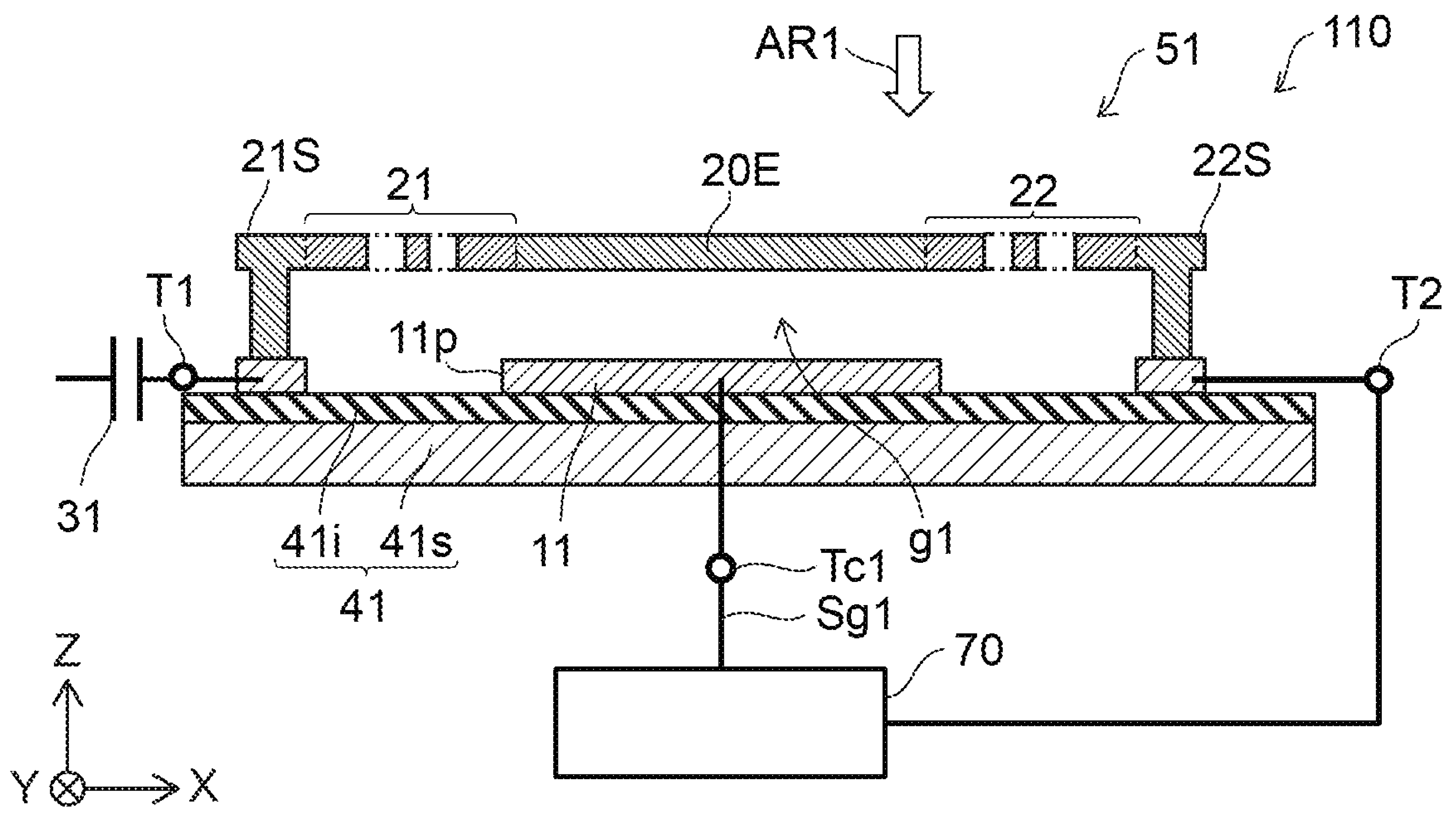
20 Claims, 21 Drawing Sheets





51
110
11
20E
21S
21
22
22S
A1
A2
21cp
W20
22cp
Y
Z
X

FIG. 1A



AR1
51
110
21S
21
20E
22
22S
T1
T2
11p
31
41i
41s
41
11
g1
Tc1
Sg1
70
Z
Y
X

FIG. 1B

FIG. 2A

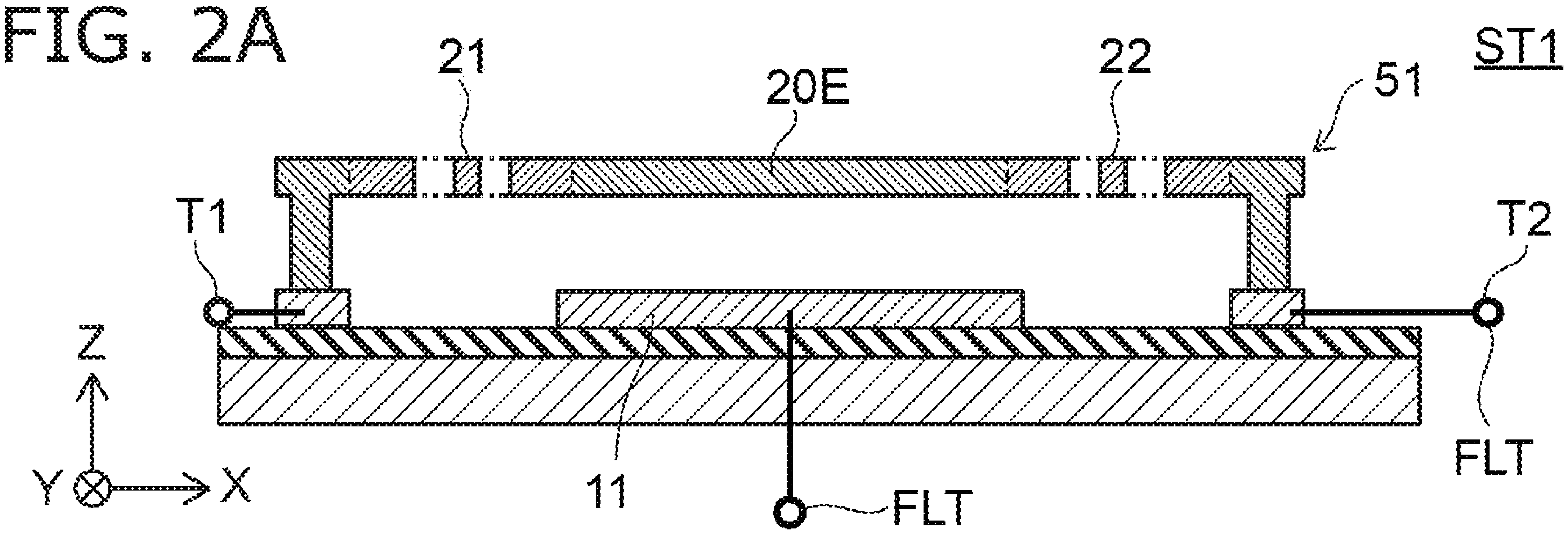


FIG. 2B

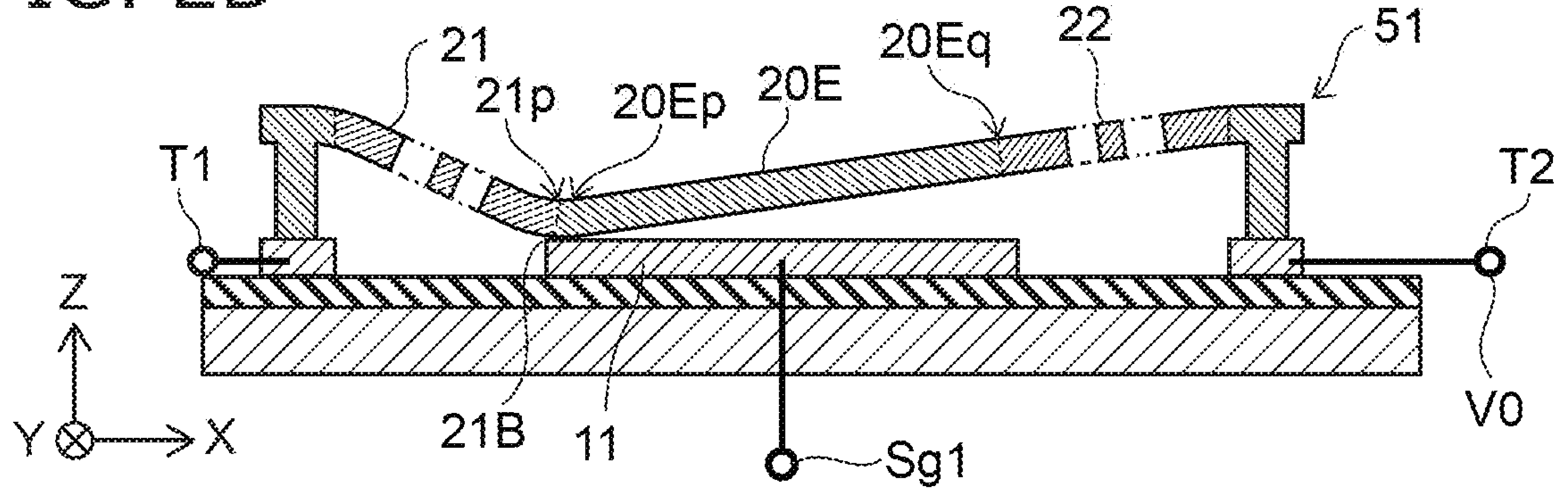


FIG. 2C

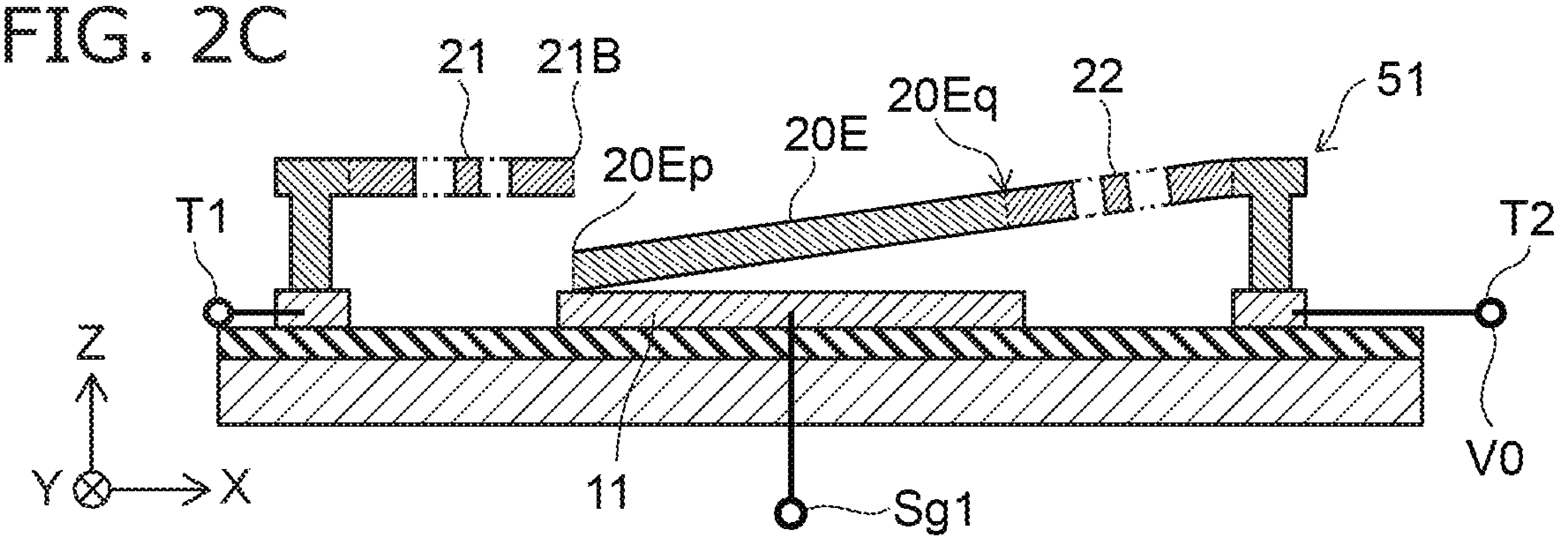


FIG. 3A

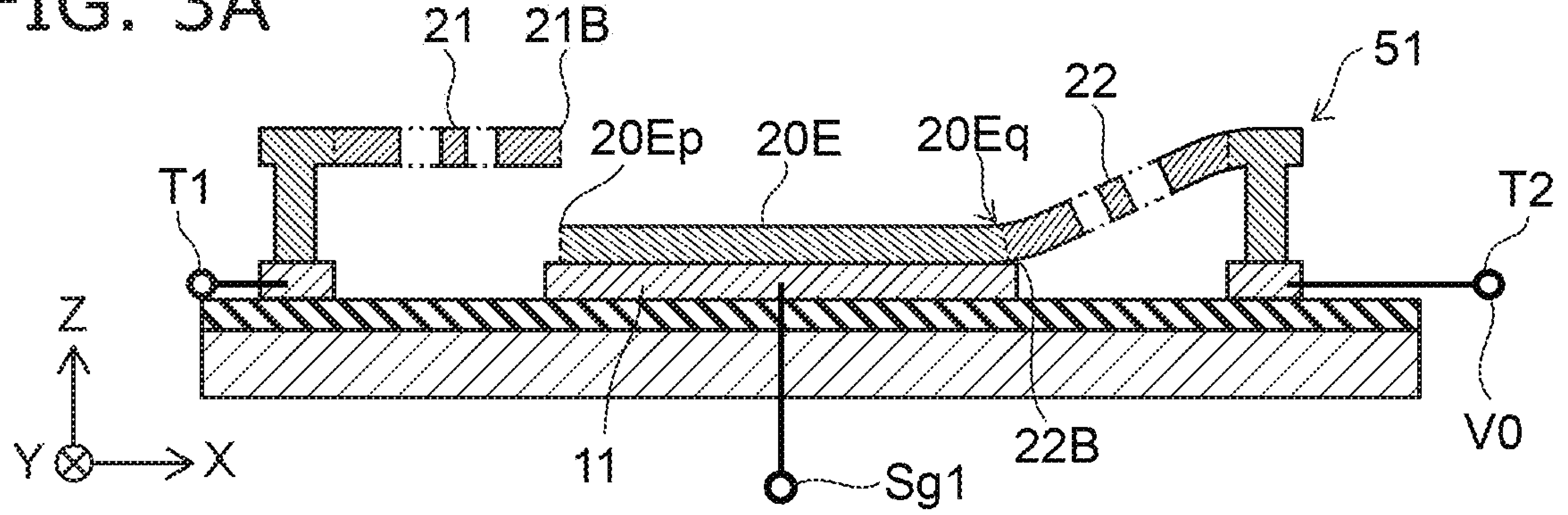
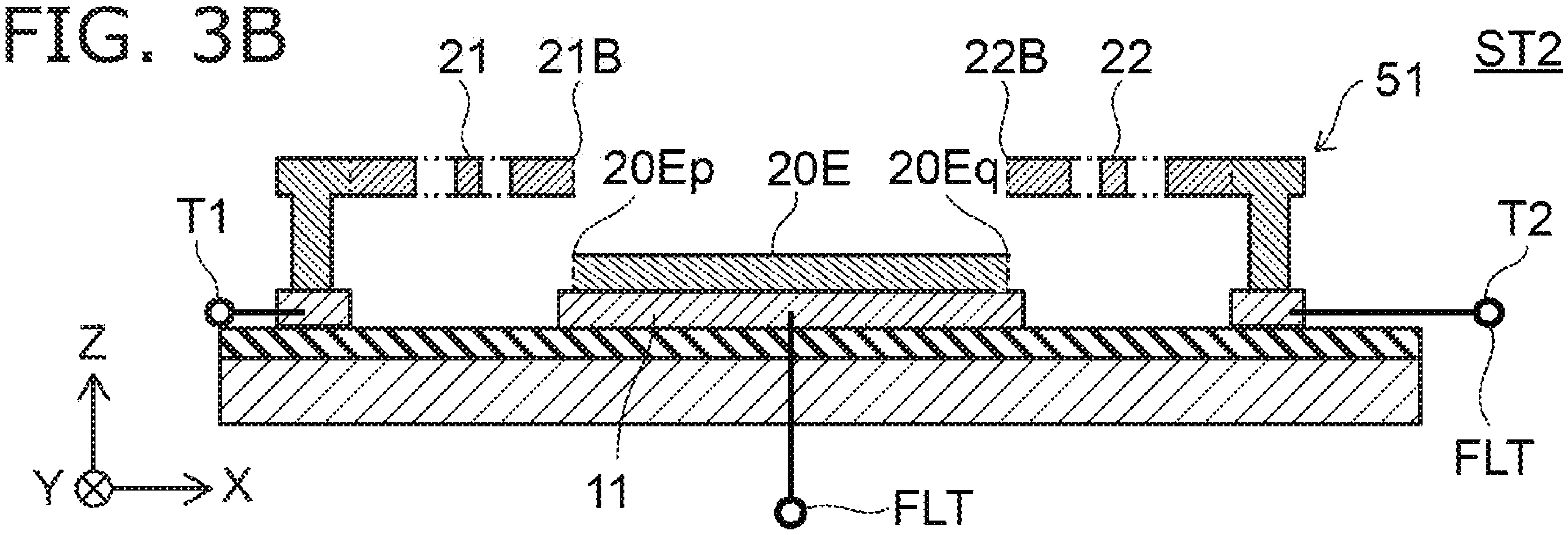

21
21B
51
22
20Ep
20E
20Eq
T1
T2
Z
Y
X
11
Sg1
22B
V0

FIG. 3B


21
21B
22B
22
ST2
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20Ep
20E
20Eq
T1
T2
Z
Y
X
11
FLT
FLT

FIG. 4A

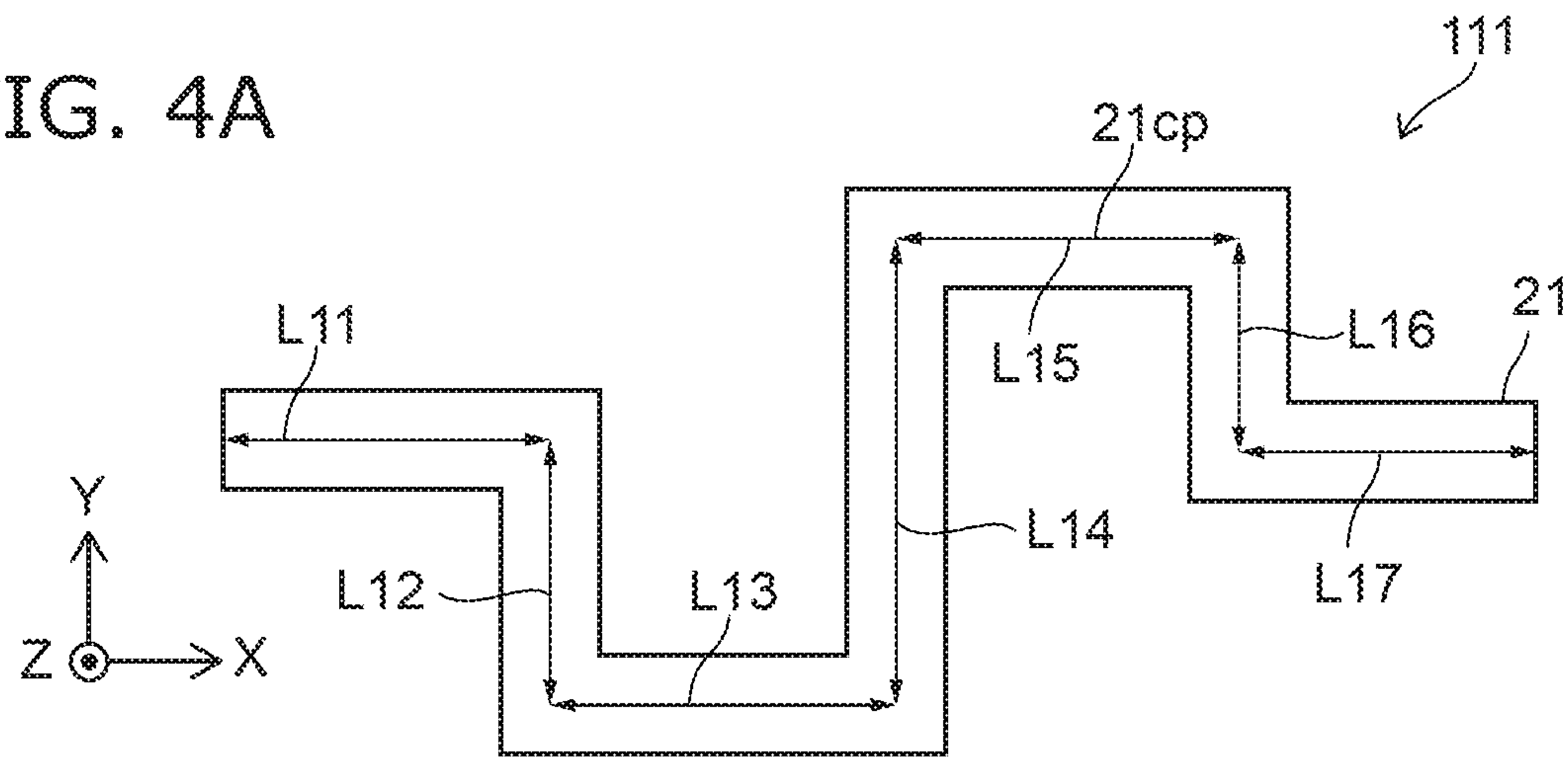

111
21cp
L11
L15
L16
21
L14
L12
L13
L17
Y
Z
X

FIG. 4B

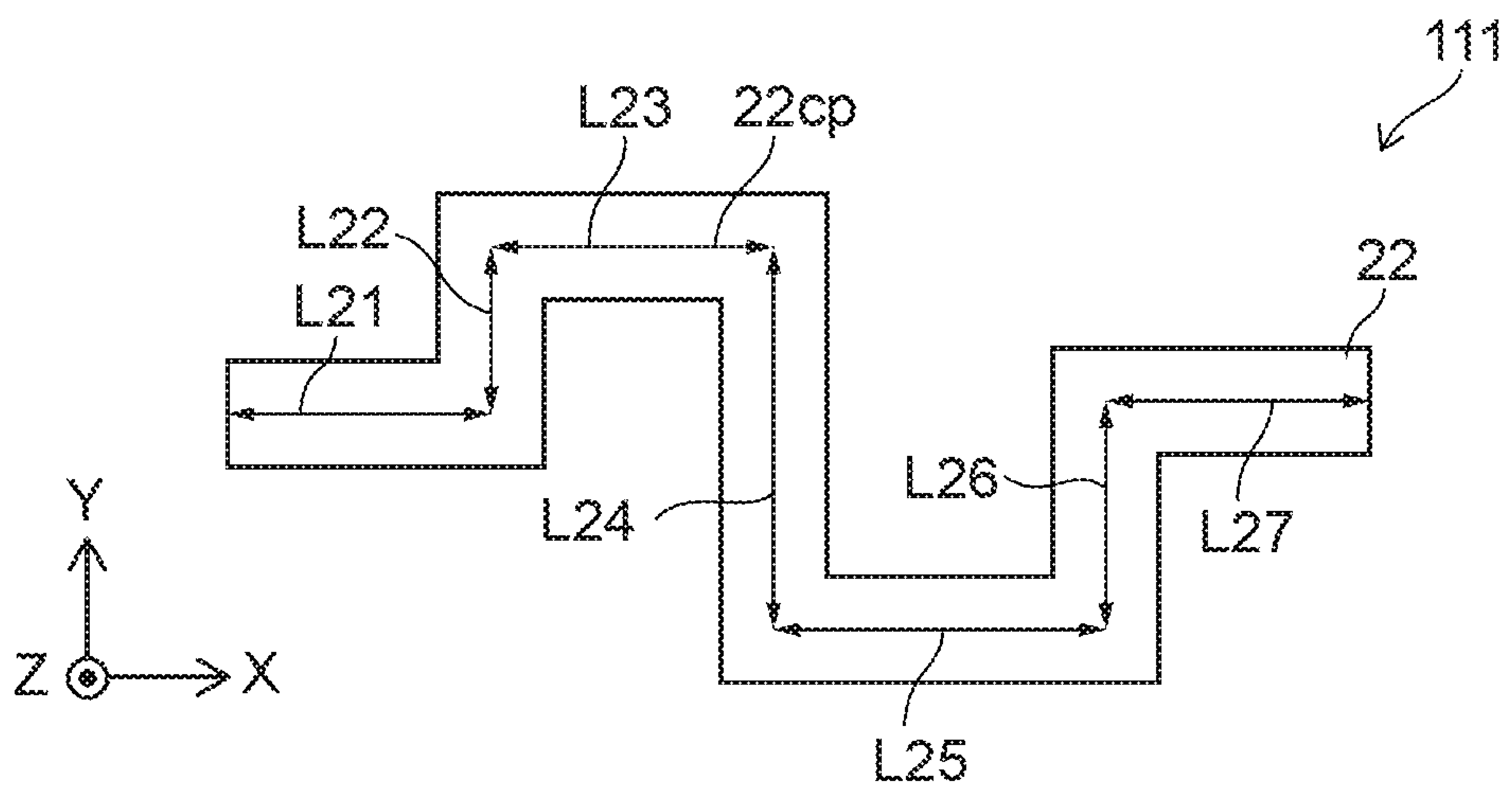

111
L23
22cp
L22
L21
22
L26
L24
L27
Y
Z
X
L25

FIG. 5A

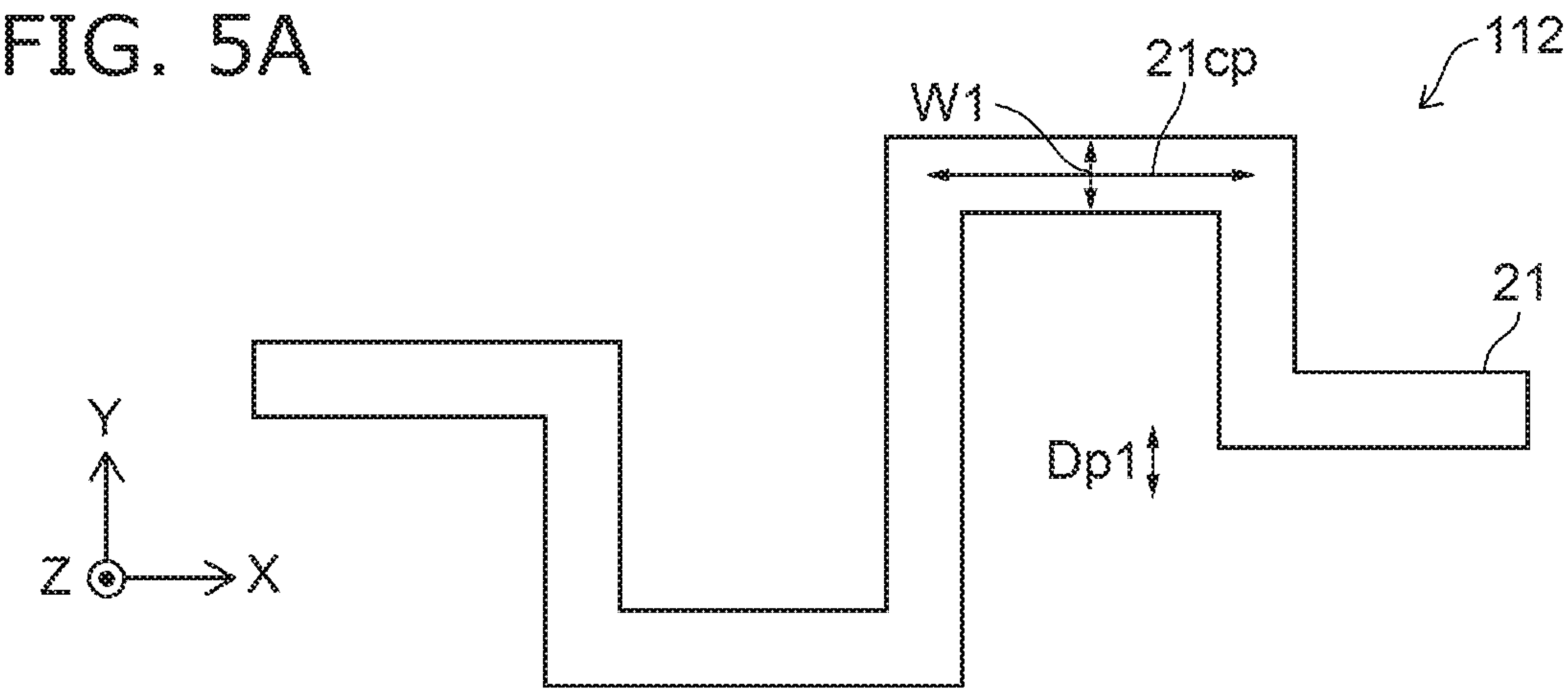


FIG. 5B

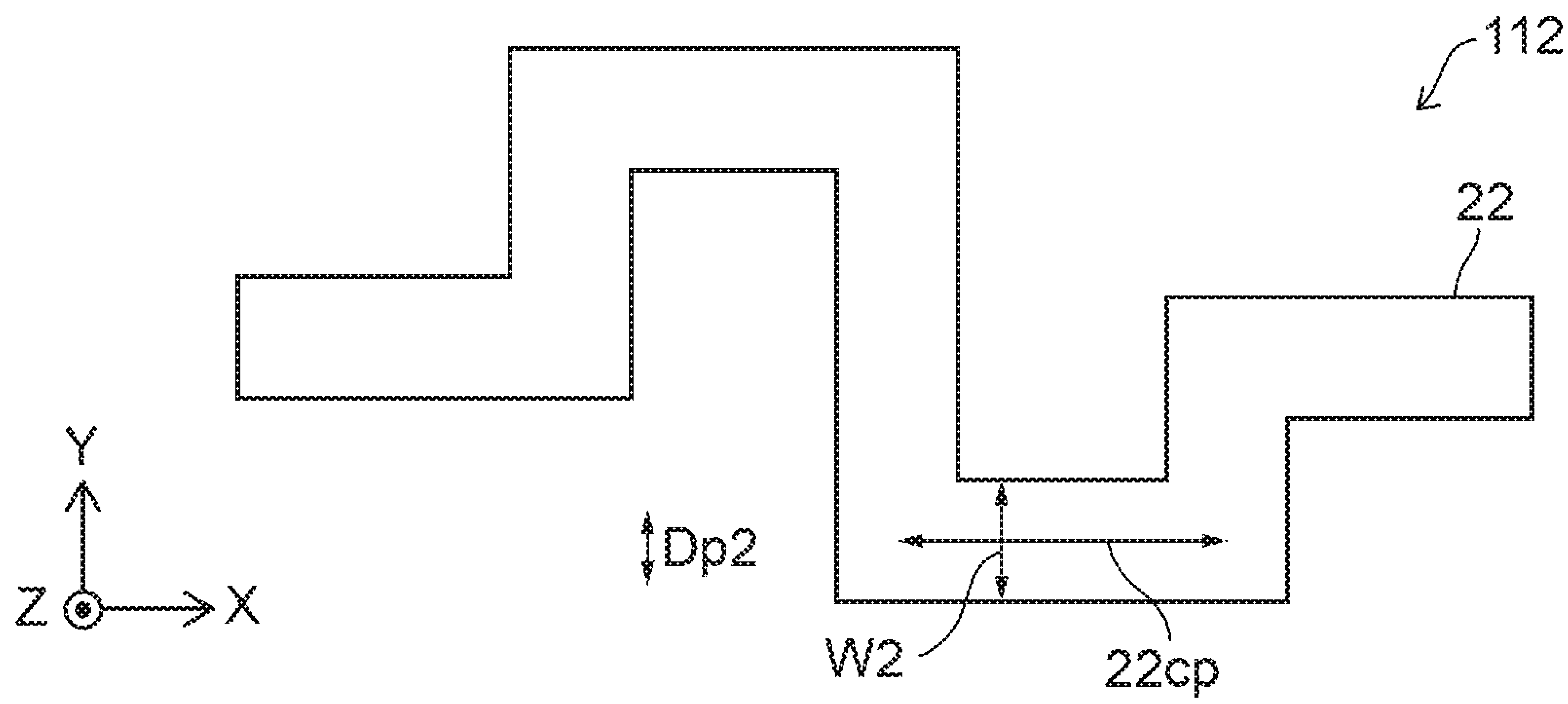


FIG. 6A

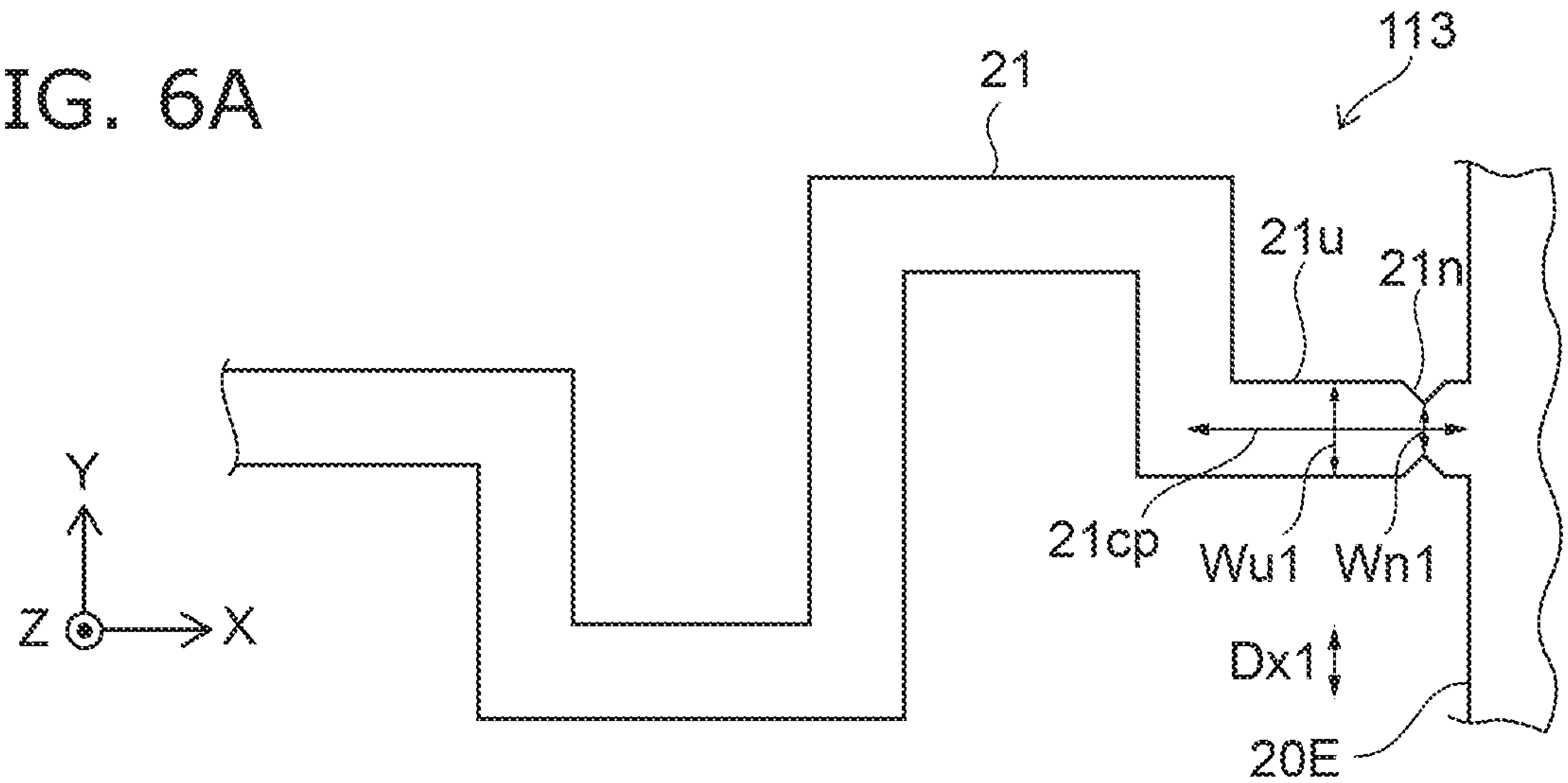

113
21
21u
21n
21cp
Wu1
Wn1
Dx1
20E
Y
Z
X

FIG. 6B

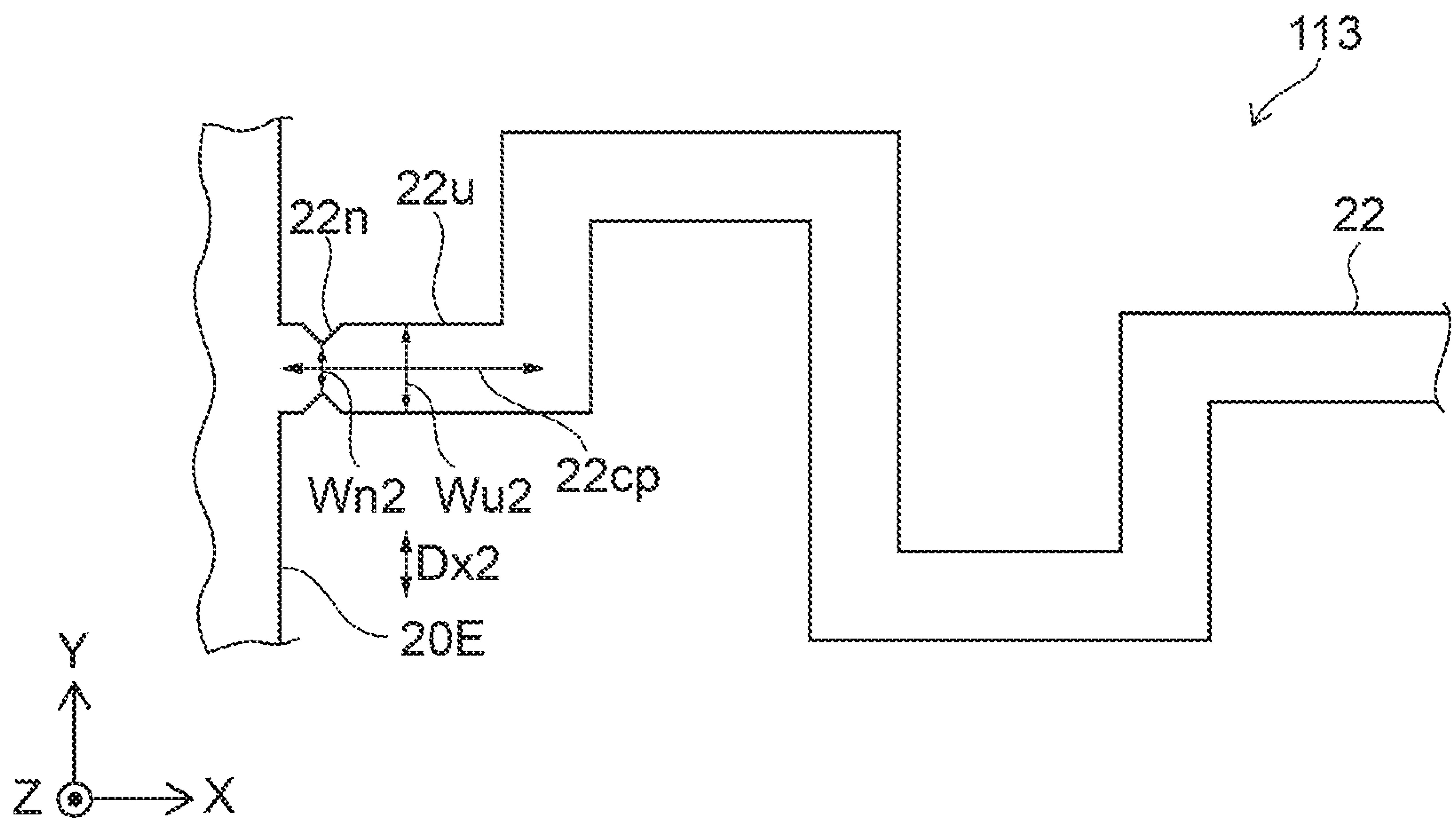

113
22
22n
22u
Wn2
Wu2
22cp
Dx2
20E
Y
Z
X

FIG. 7A

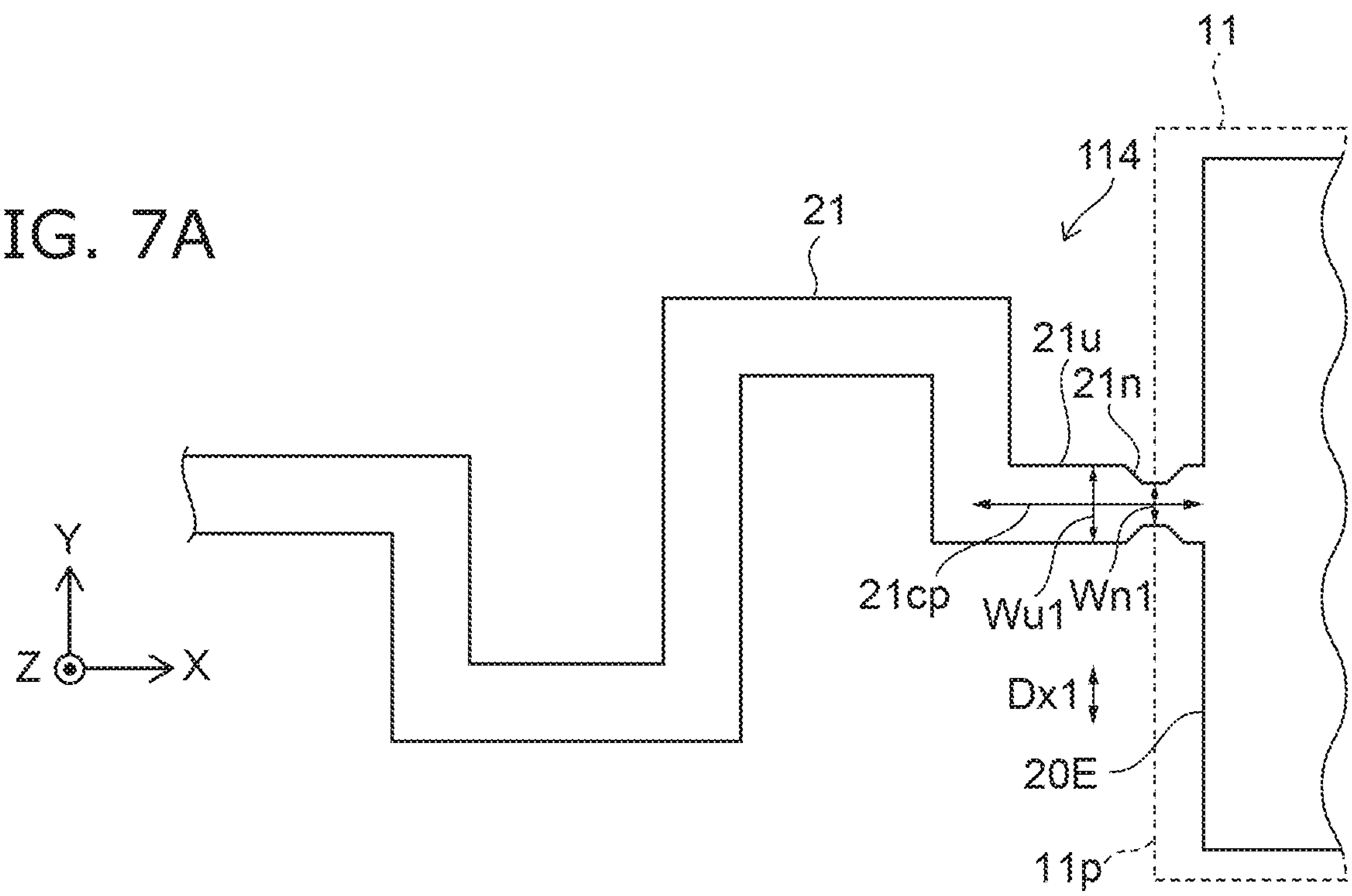

11
114
21
21u
21n
21cp
Wu1
Wn1
Y
Z
X
Dx1
20E
11p

FIG. 7B

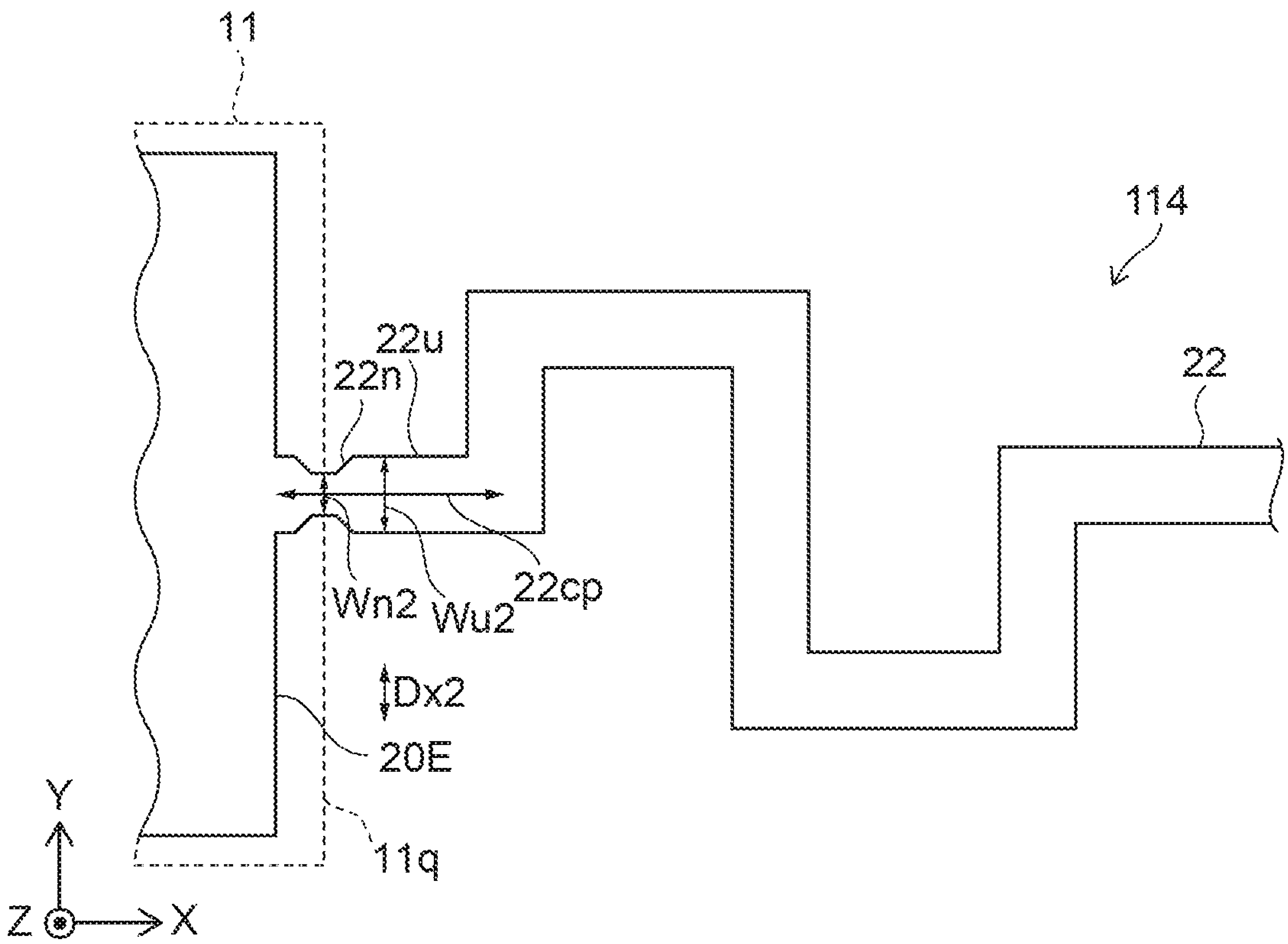

11
114
22u
22n
22
Wn2
Wu2
22cp
Dx2
20E
11q
Y
Z
X

FIG. 8A

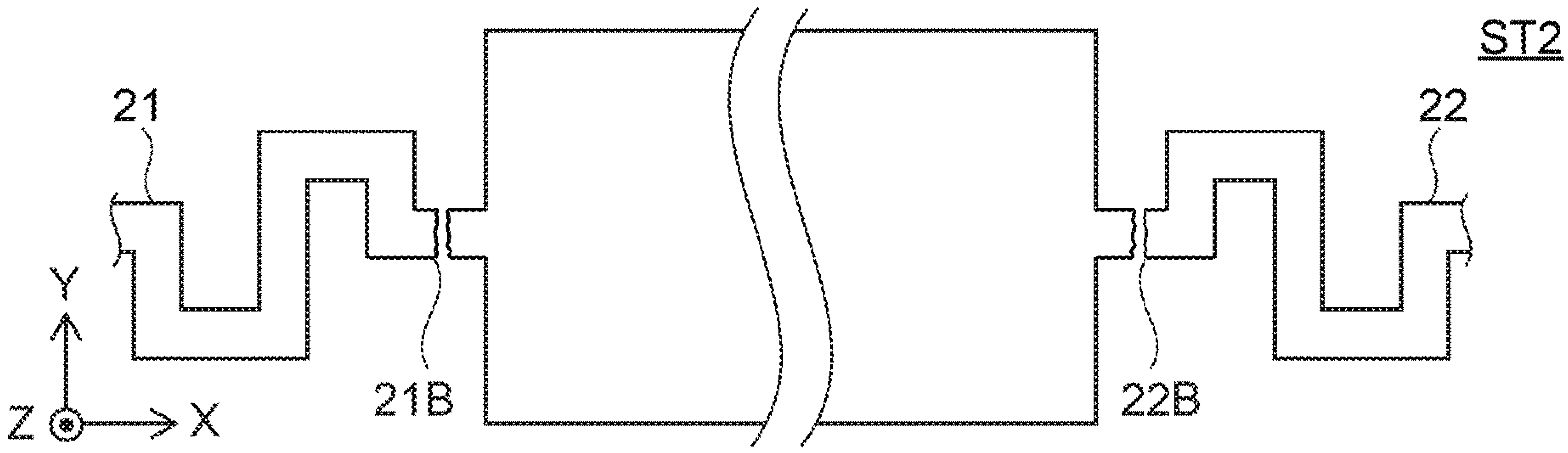


FIG. 8B

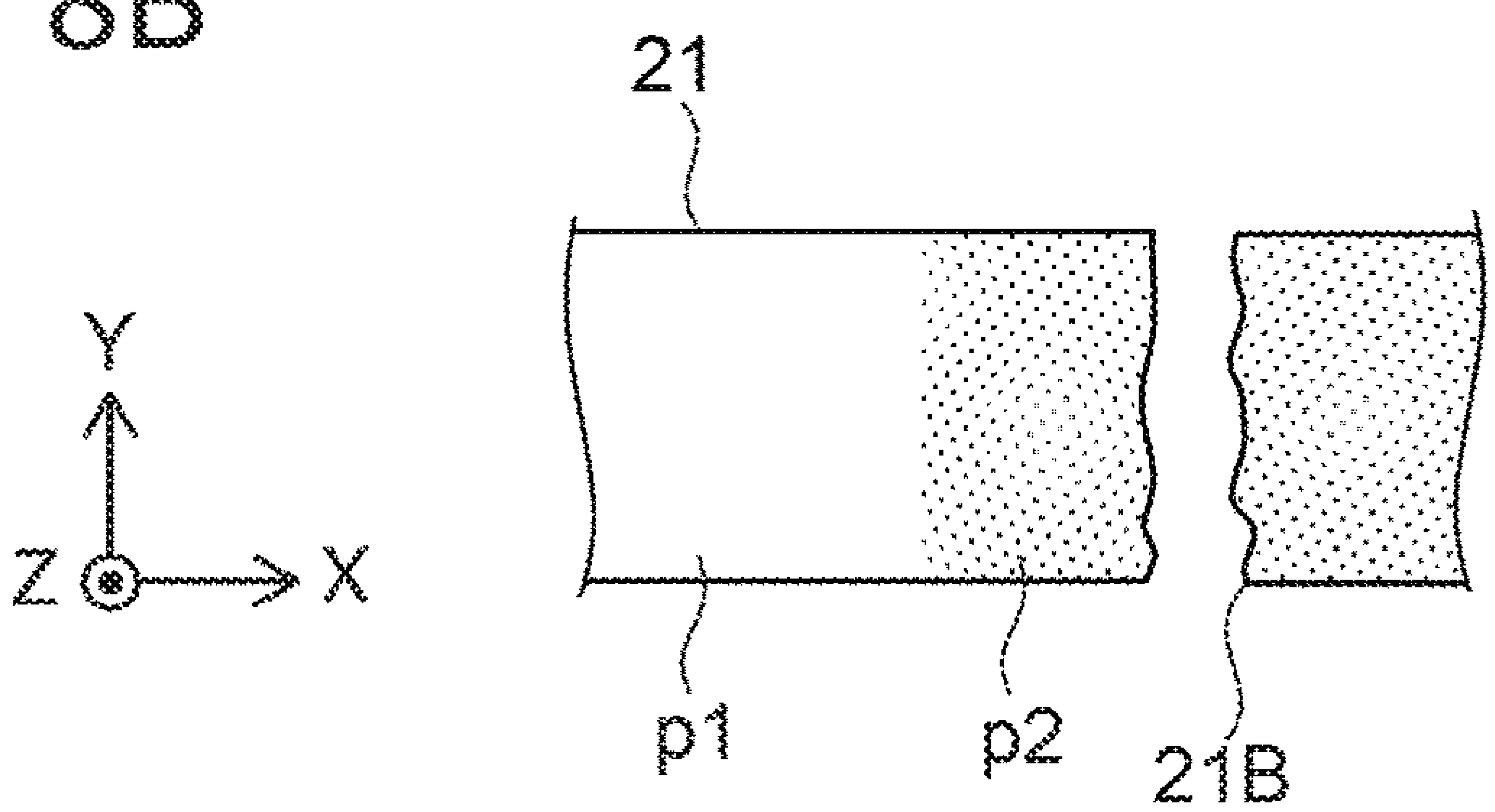
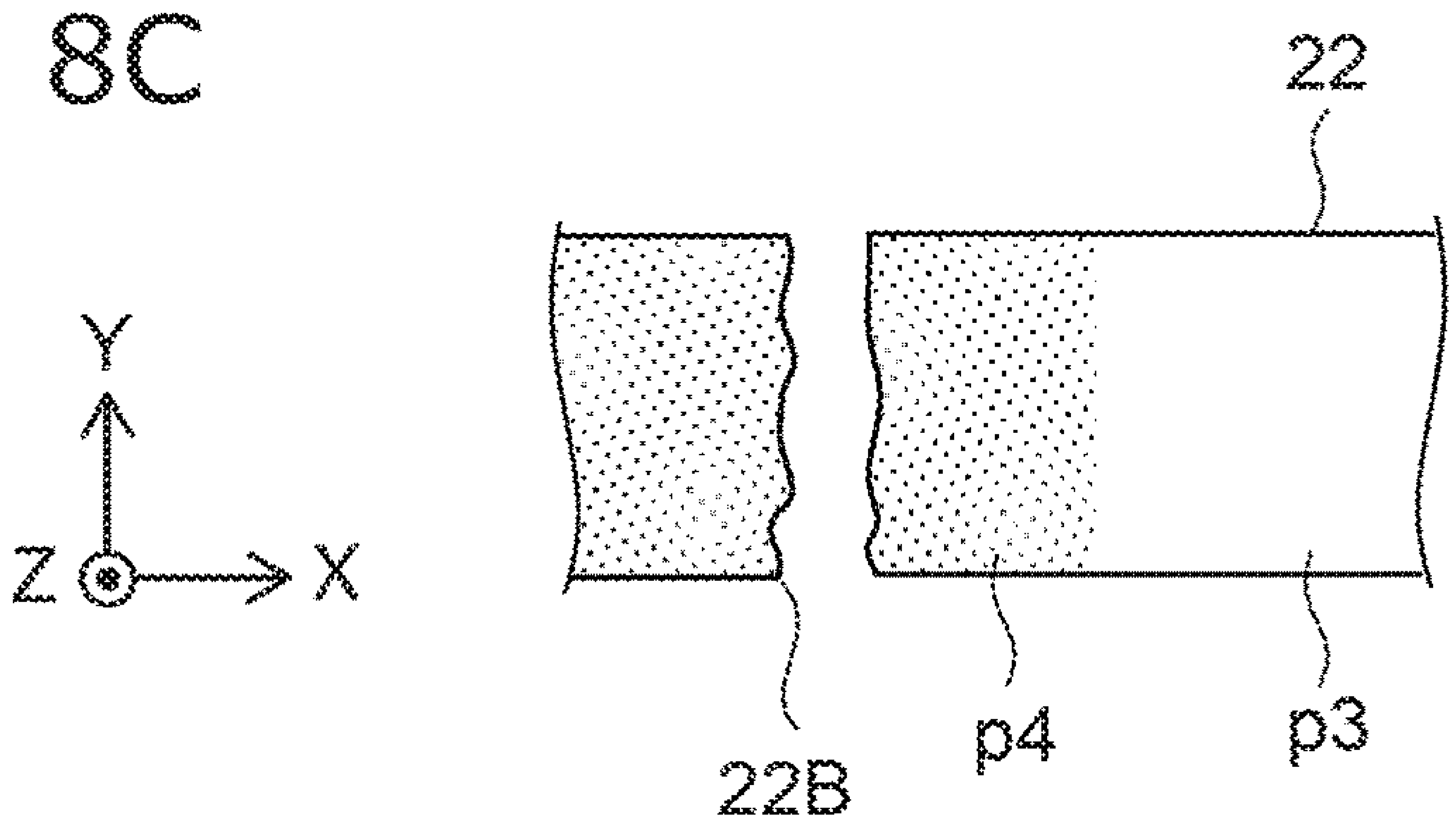


FIG. 8C



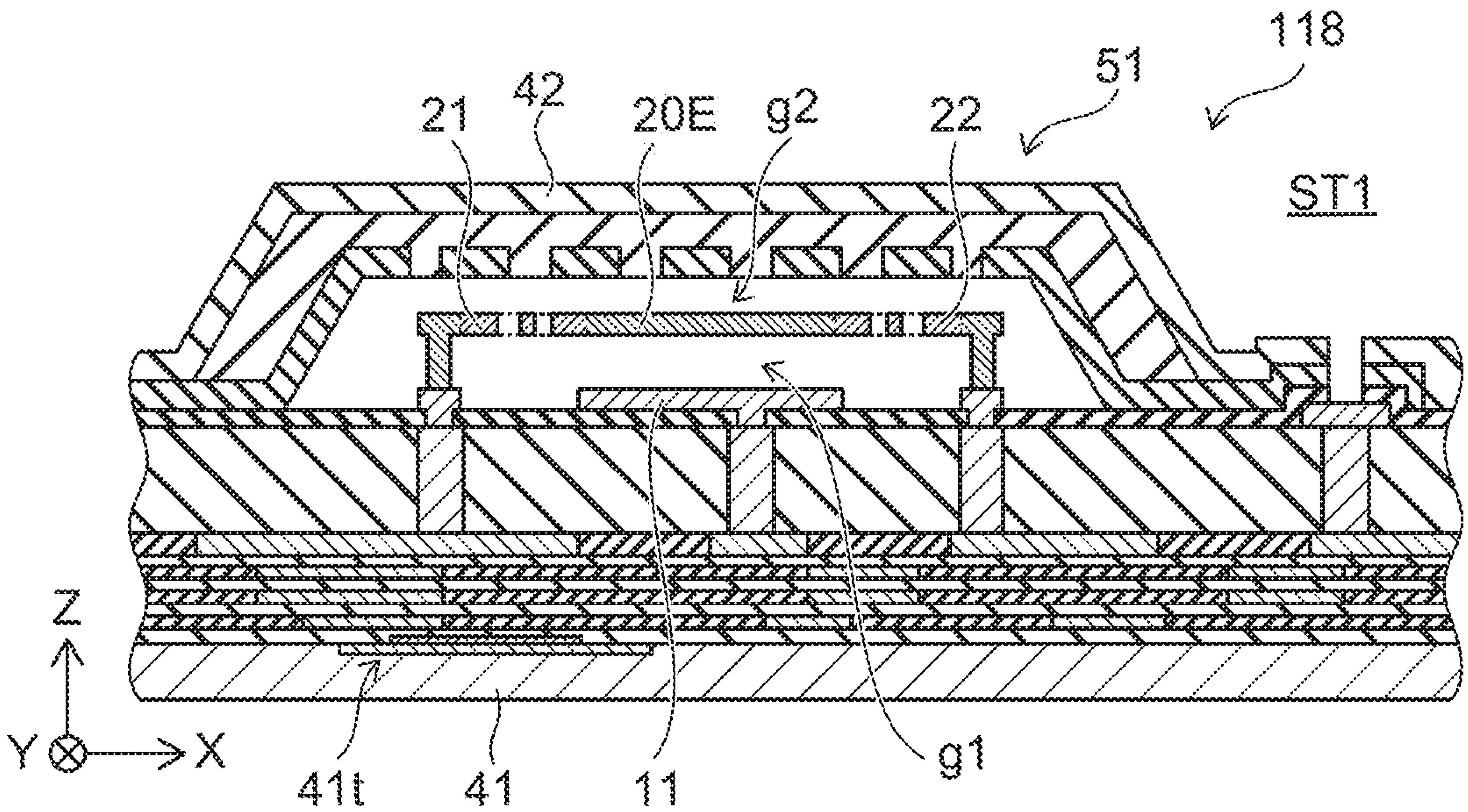


FIG. 9

FIG. 10A

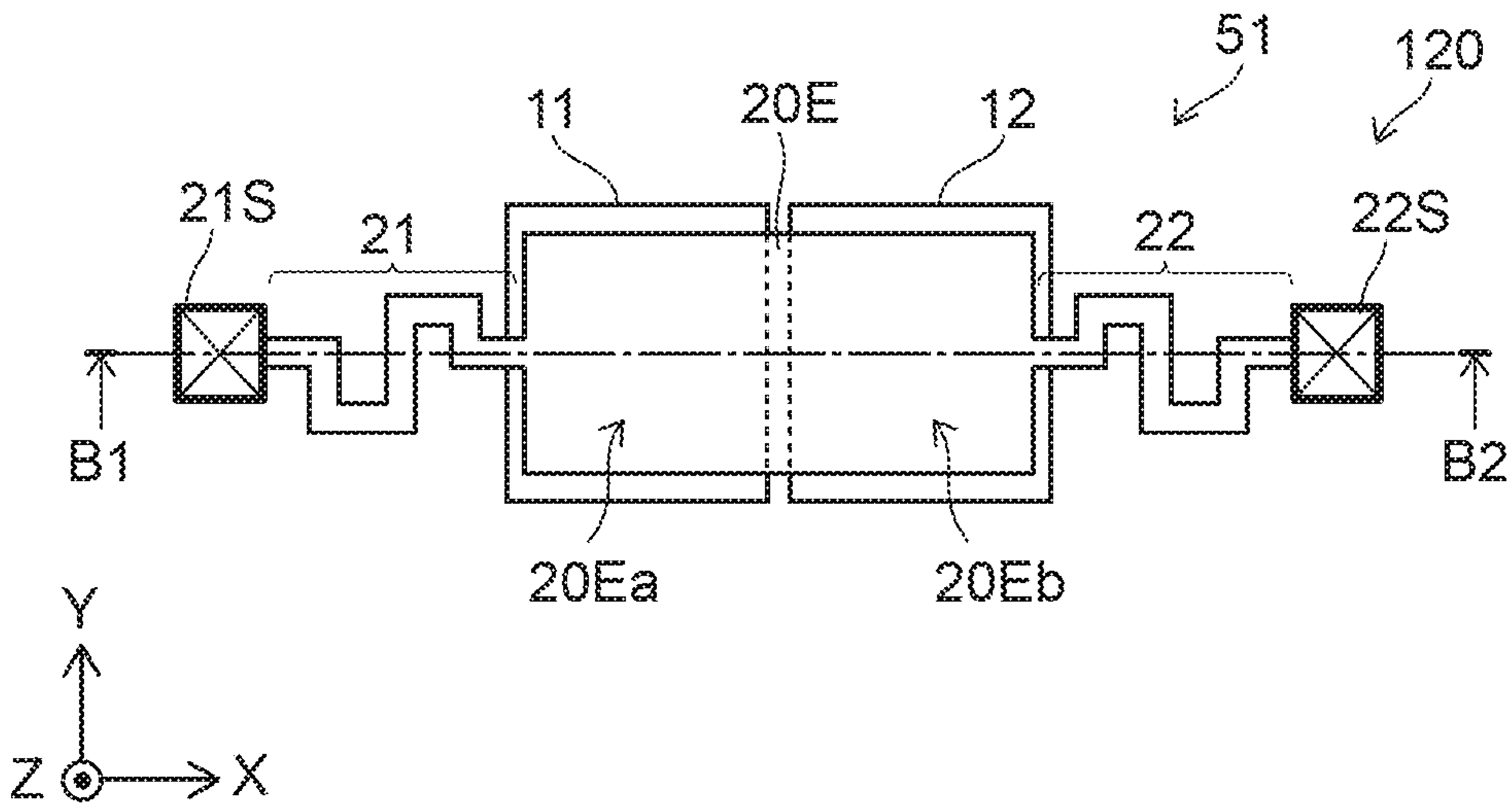


FIG. 10B

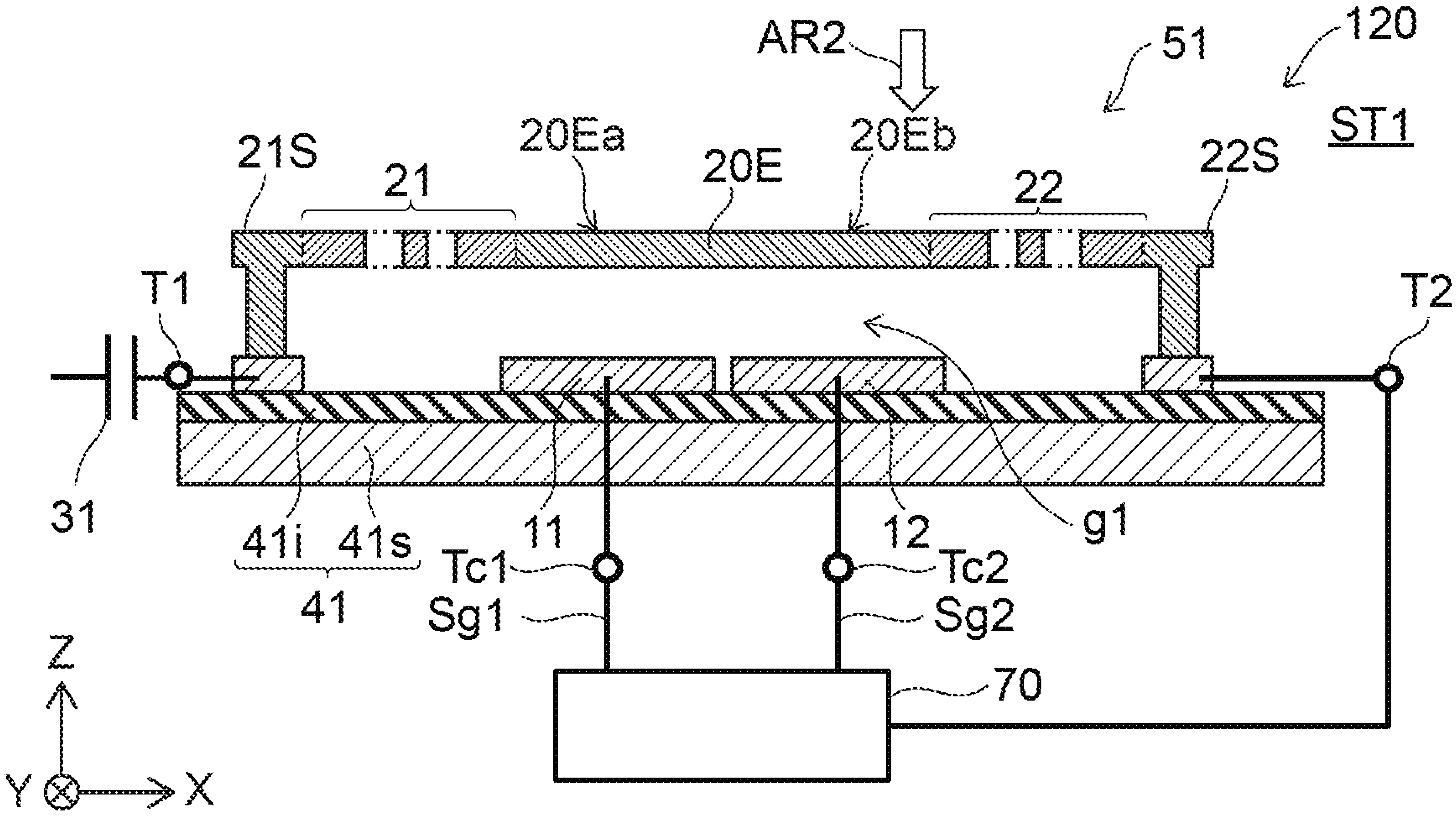


FIG. 11A

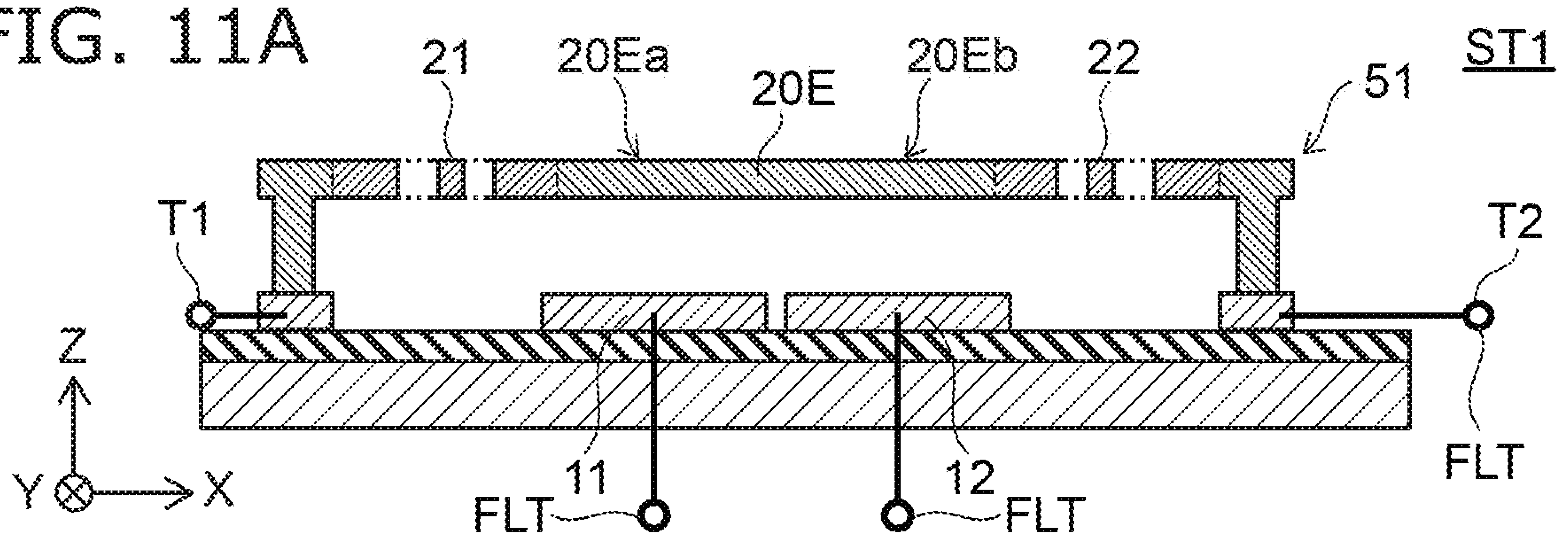


FIG. 11B

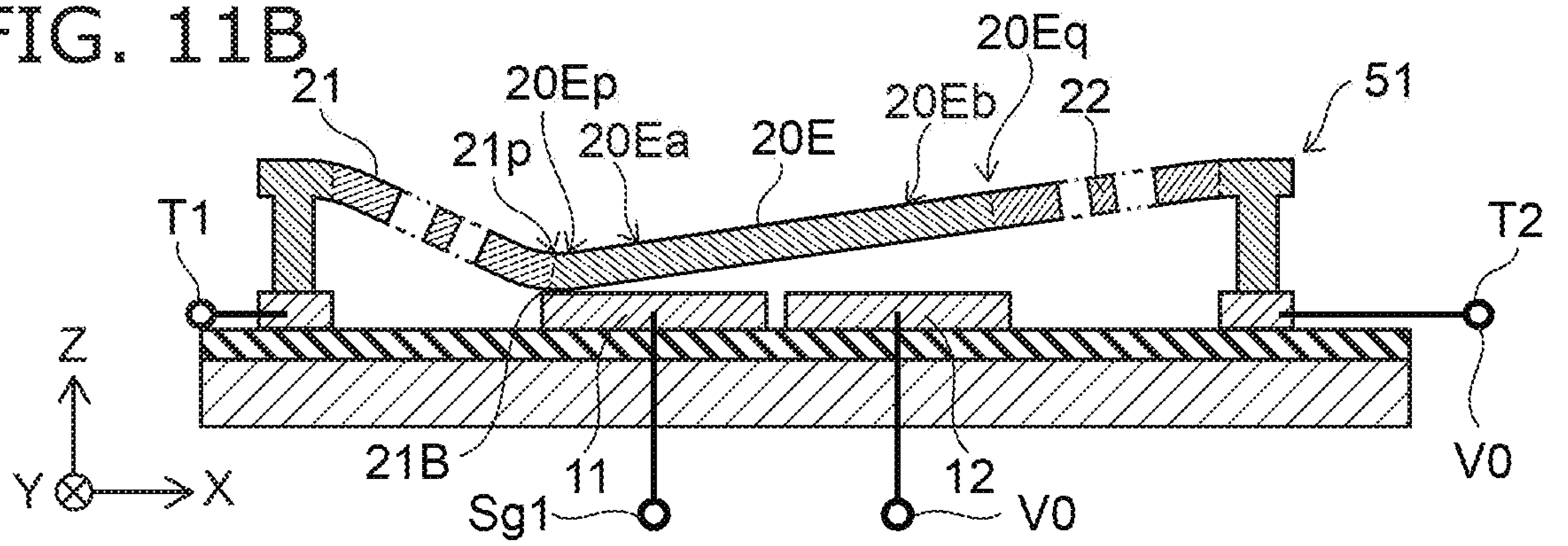


FIG. 11C

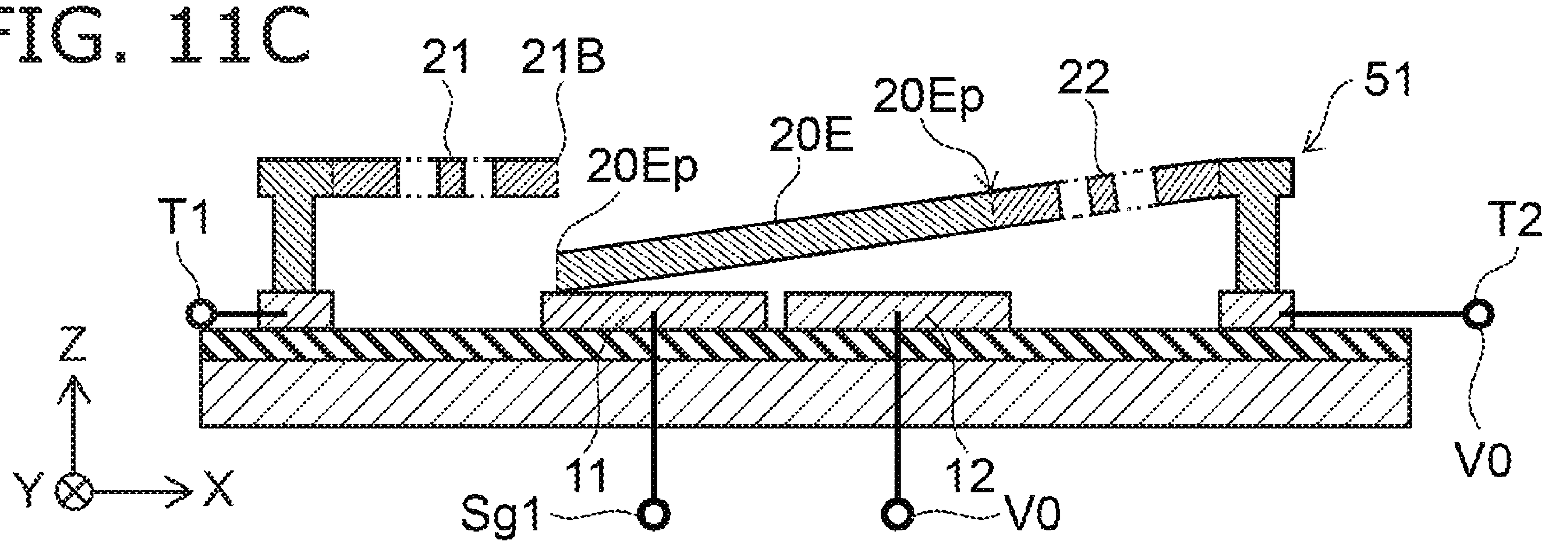


FIG. 12A

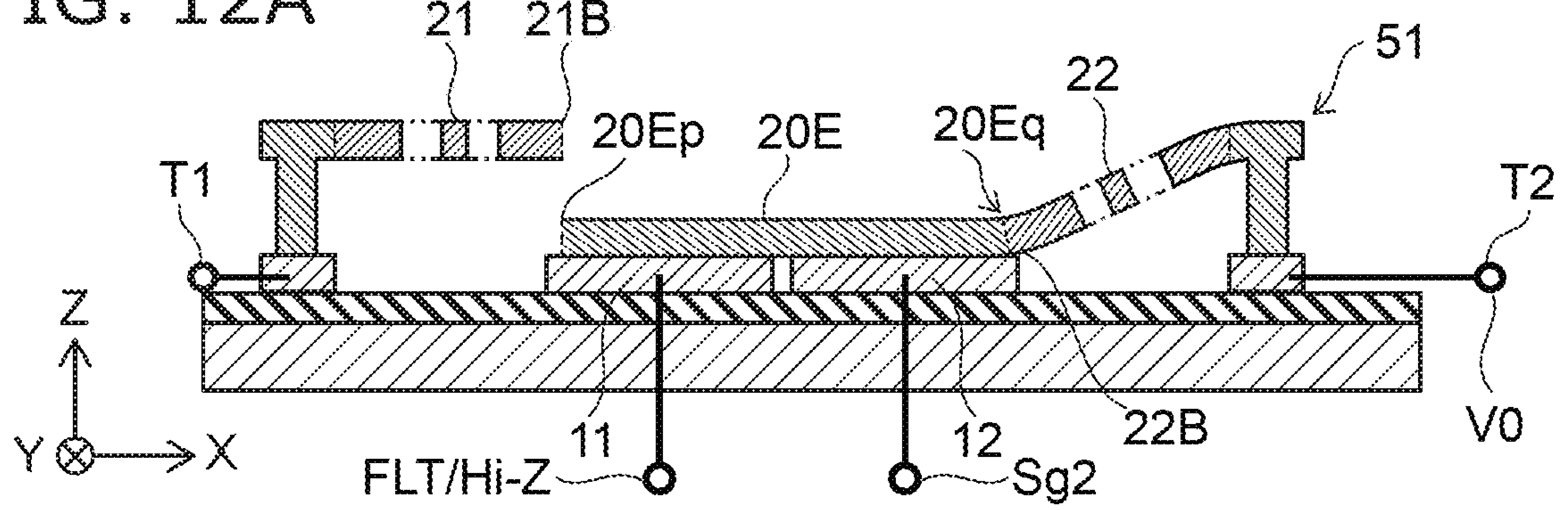
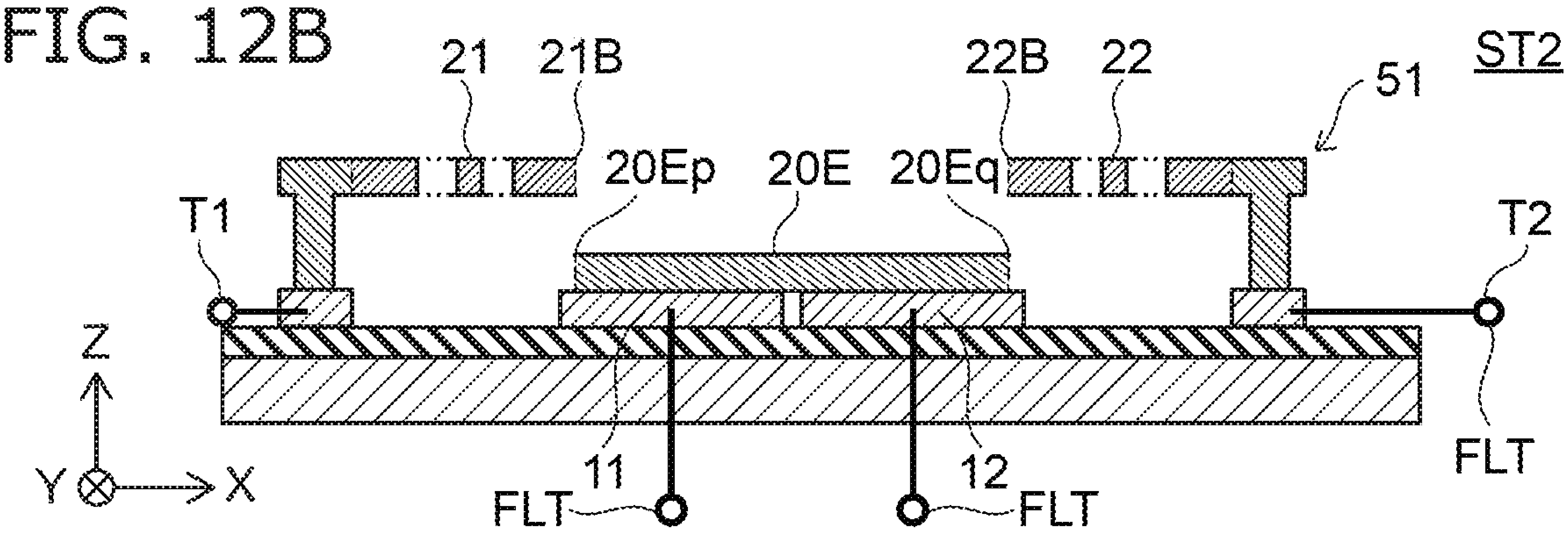


FIG. 12B



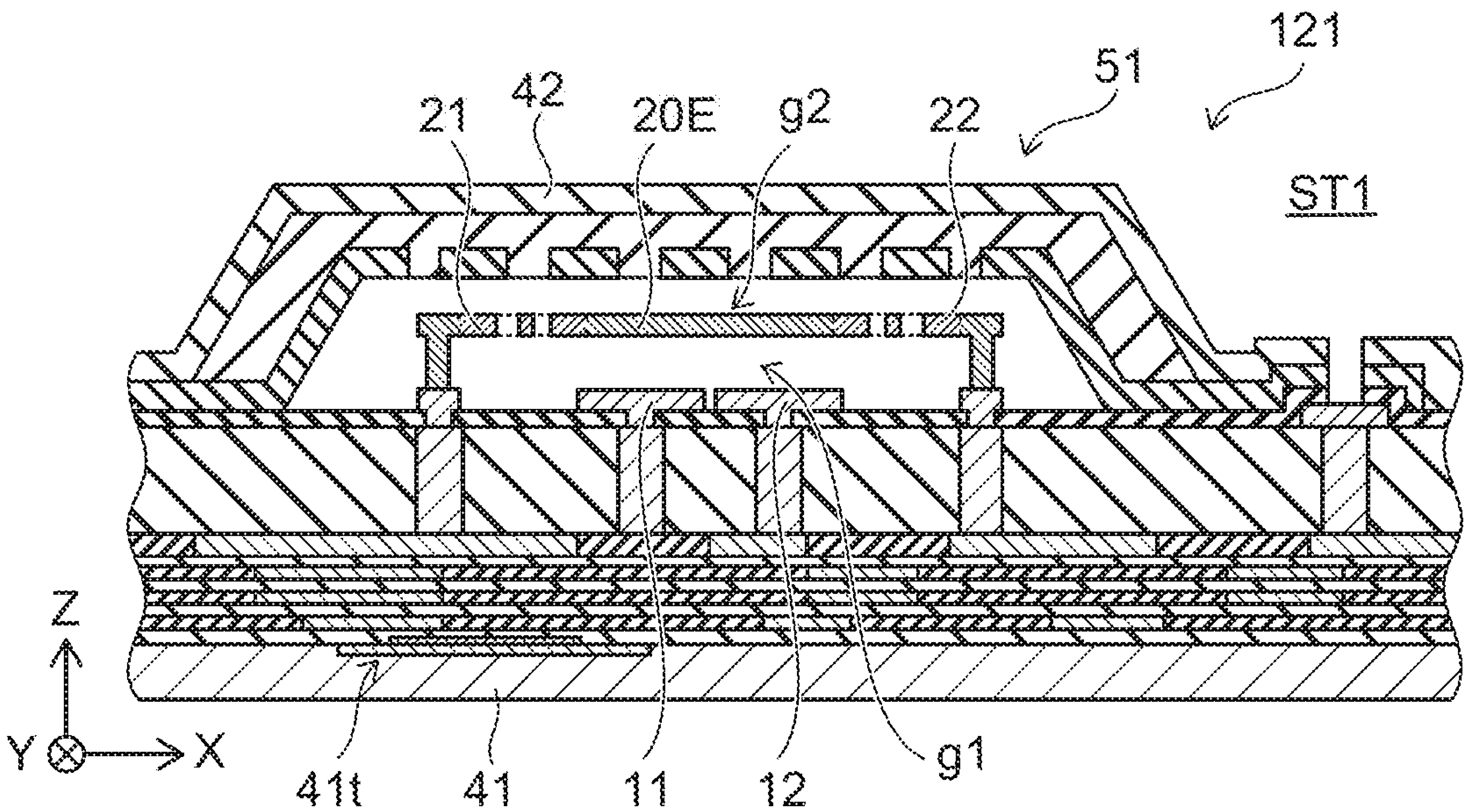


FIG. 13

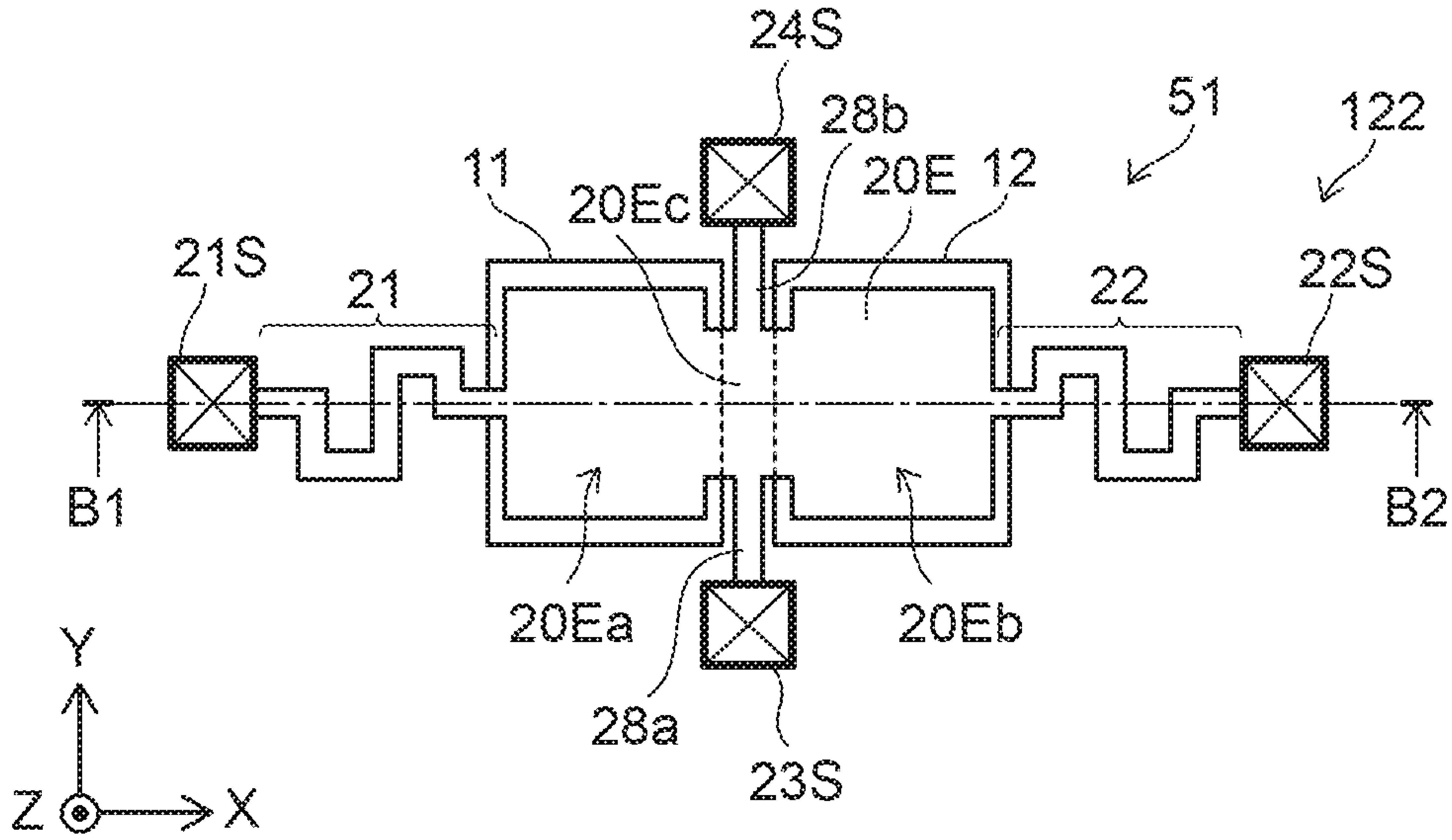


FIG. 14A

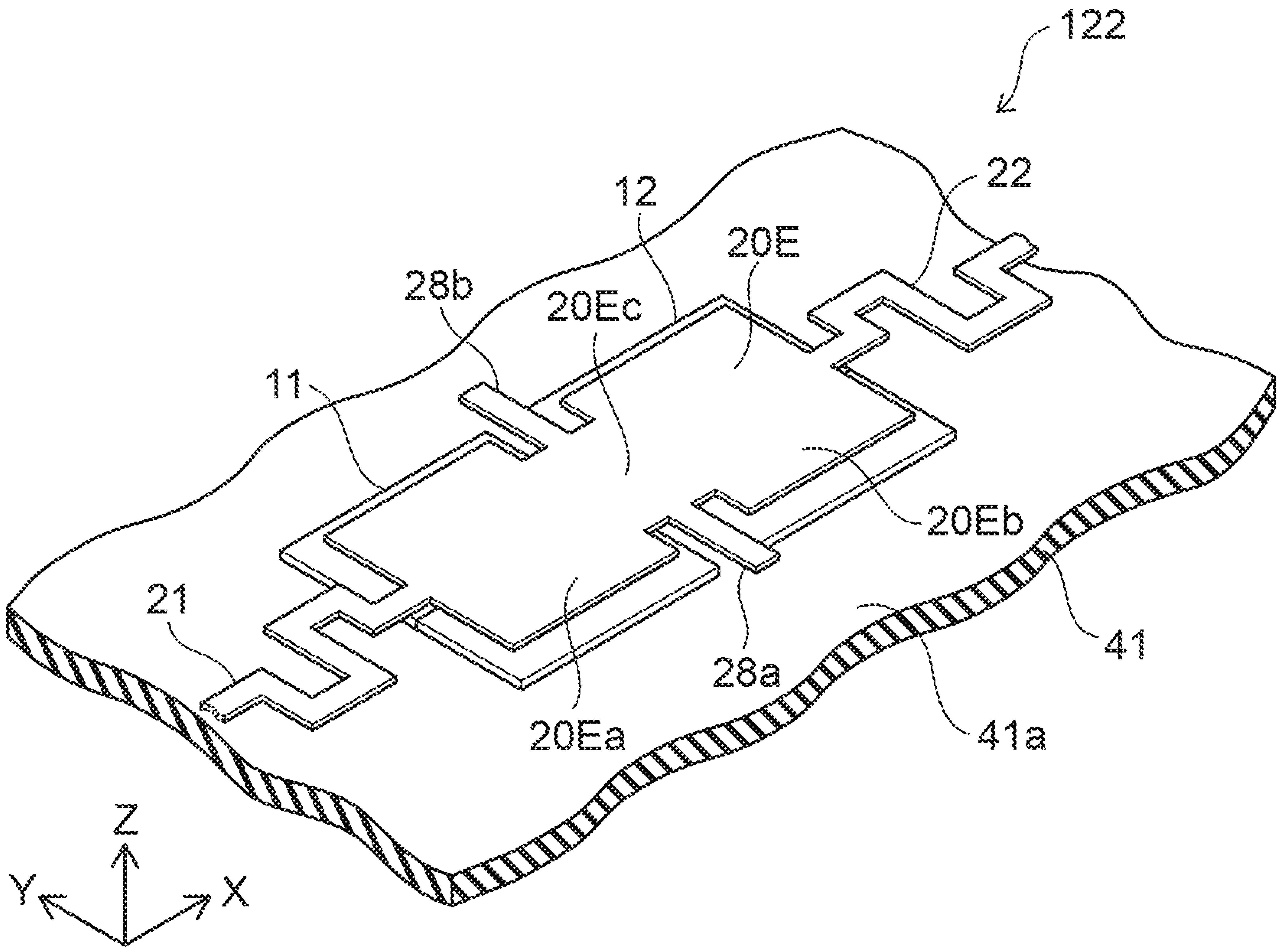


FIG. 14B

FIG. 15A

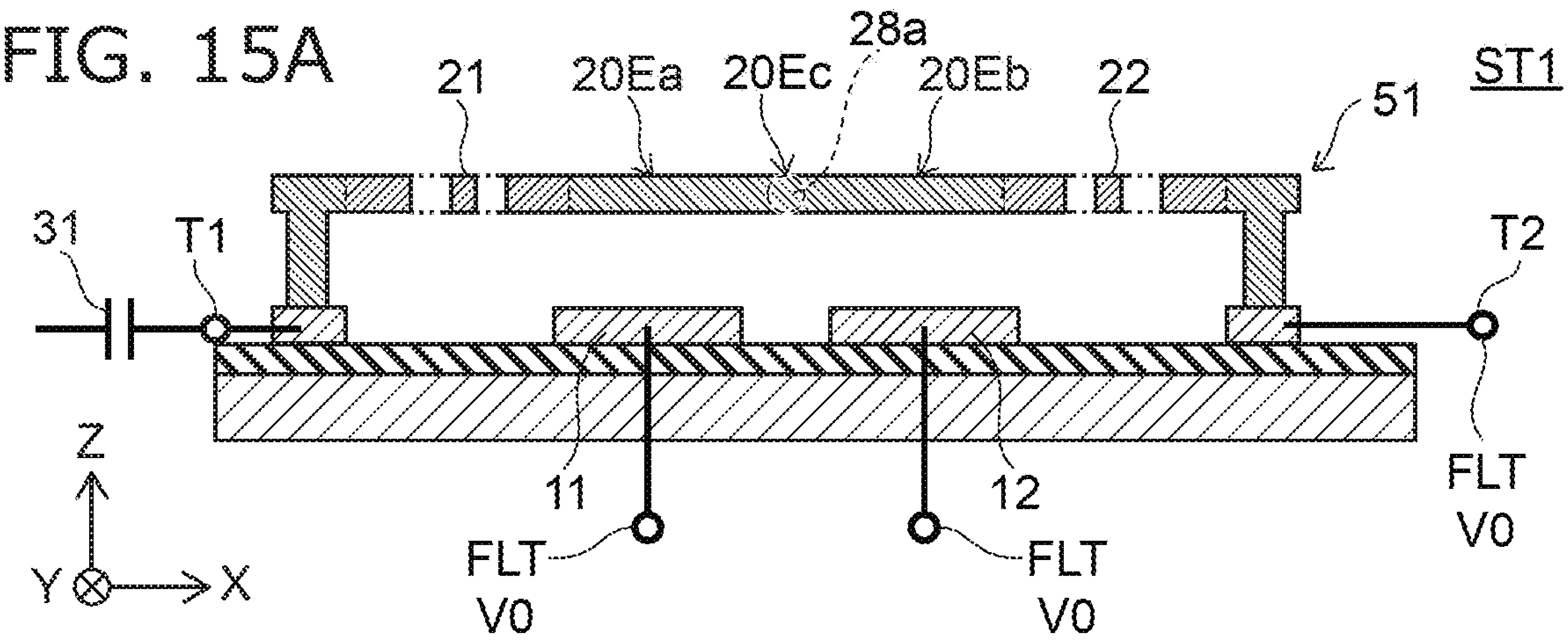


FIG. 15B

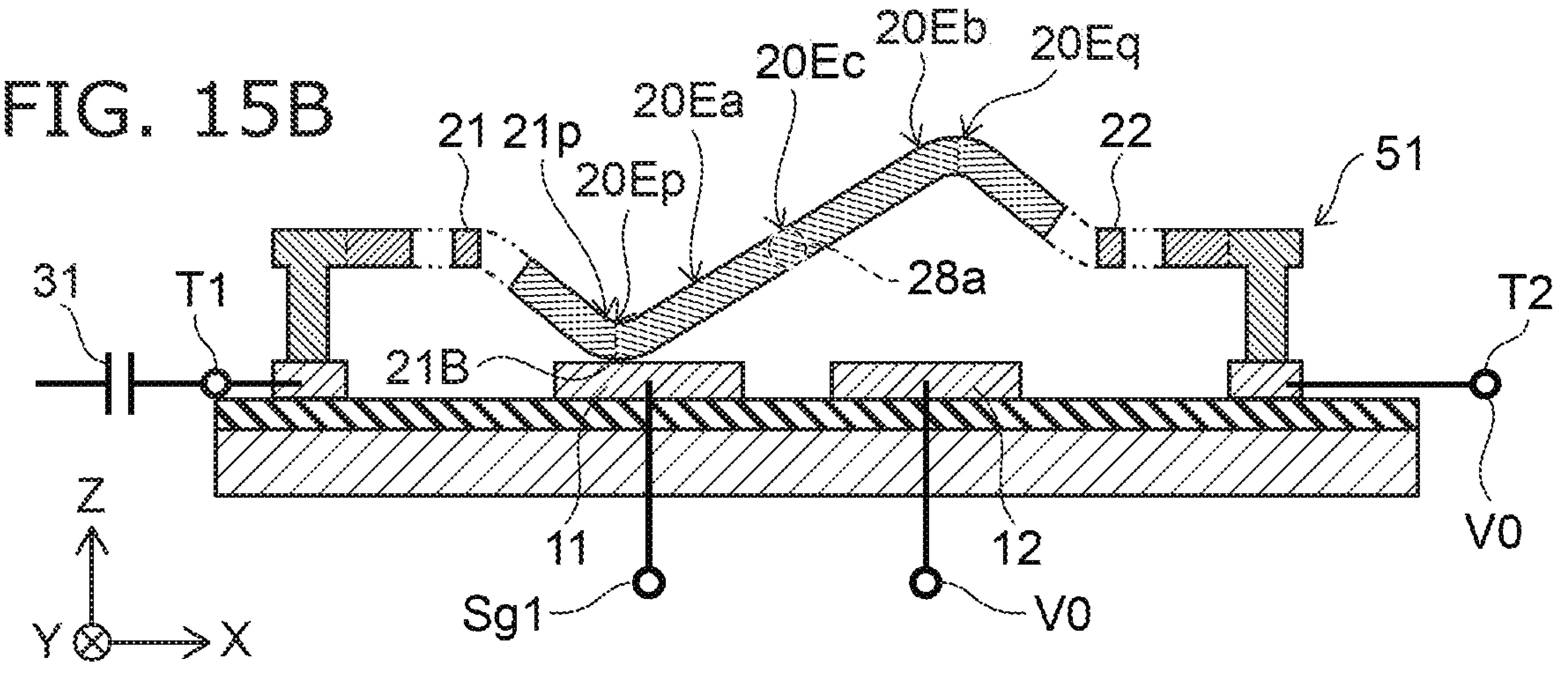


FIG. 15C

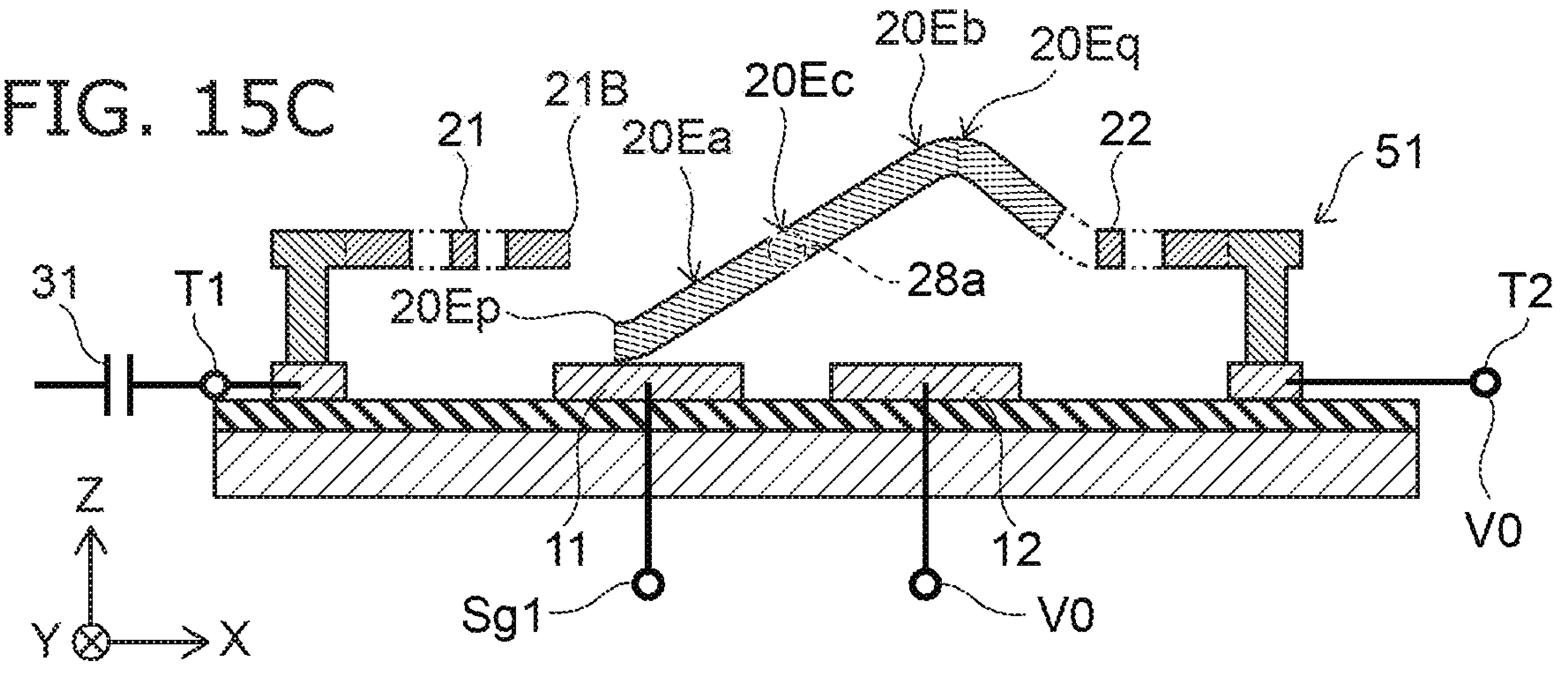


FIG. 16A

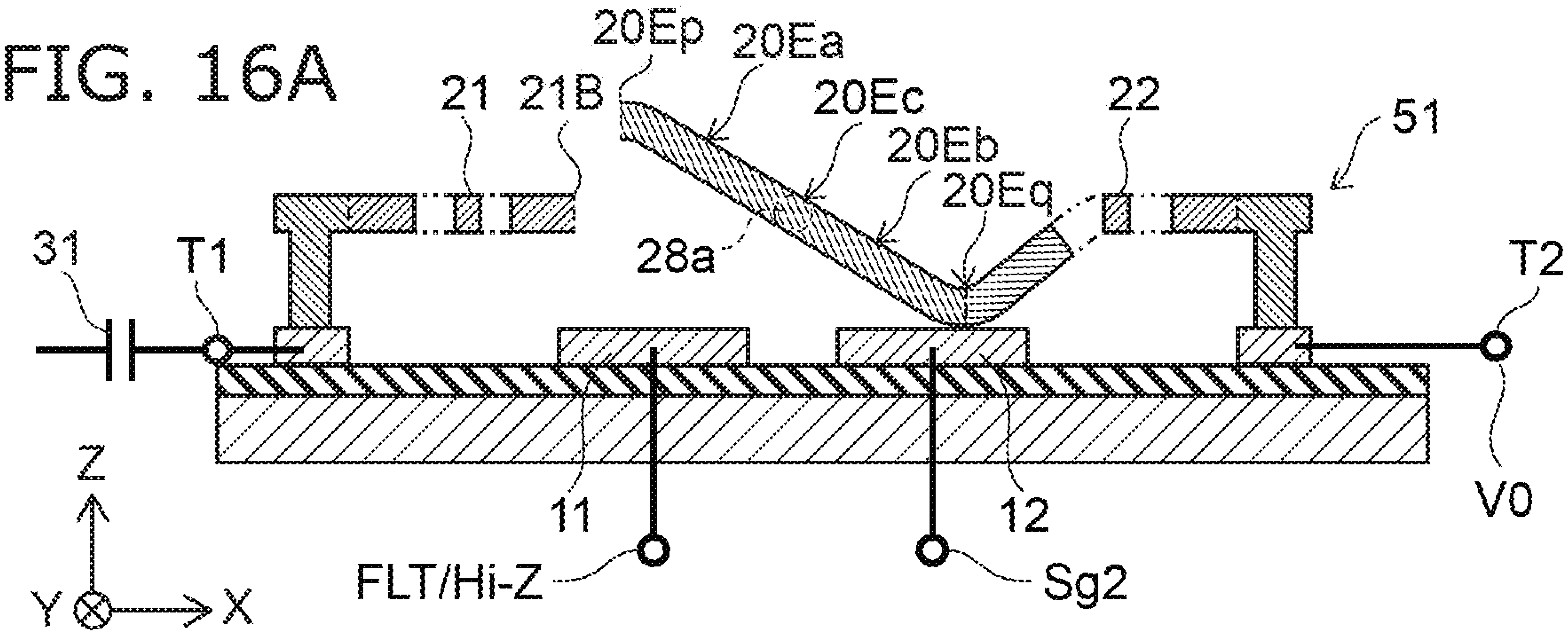


FIG. 16B

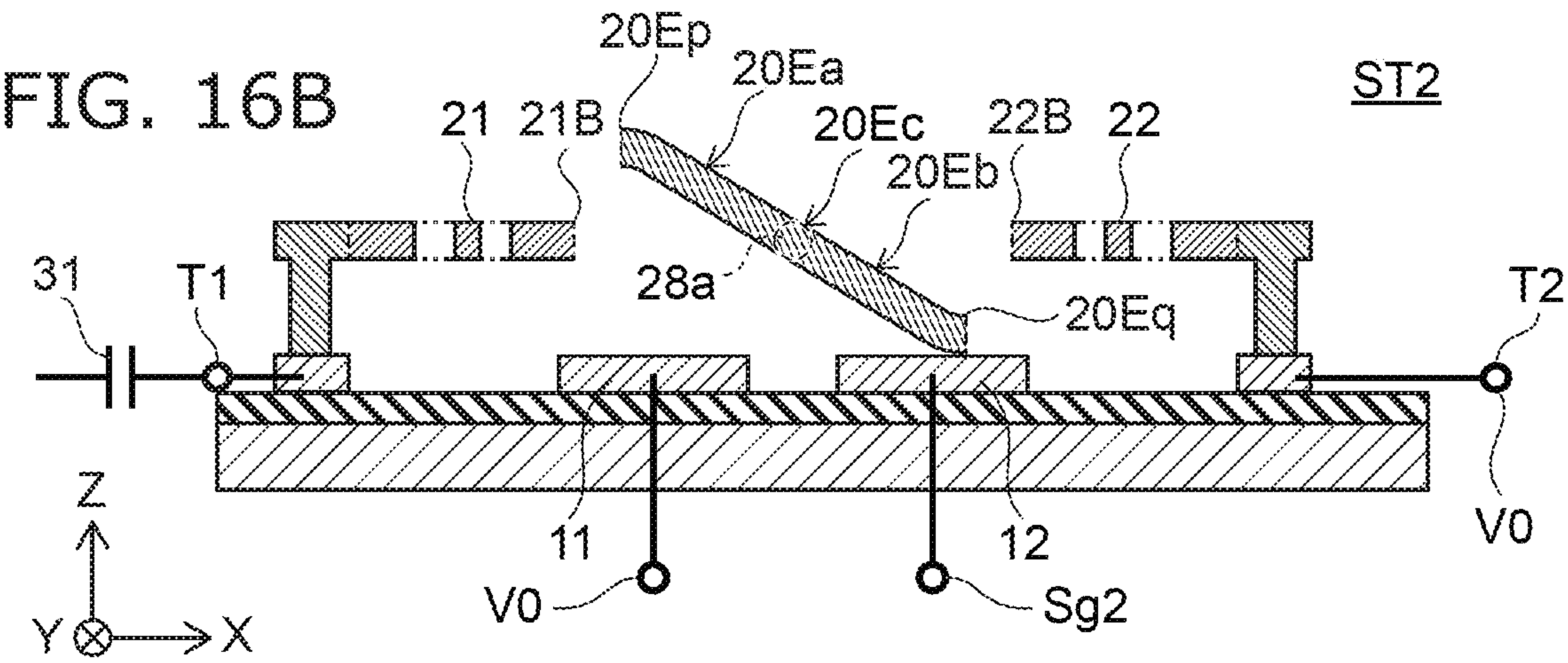


FIG. 16C

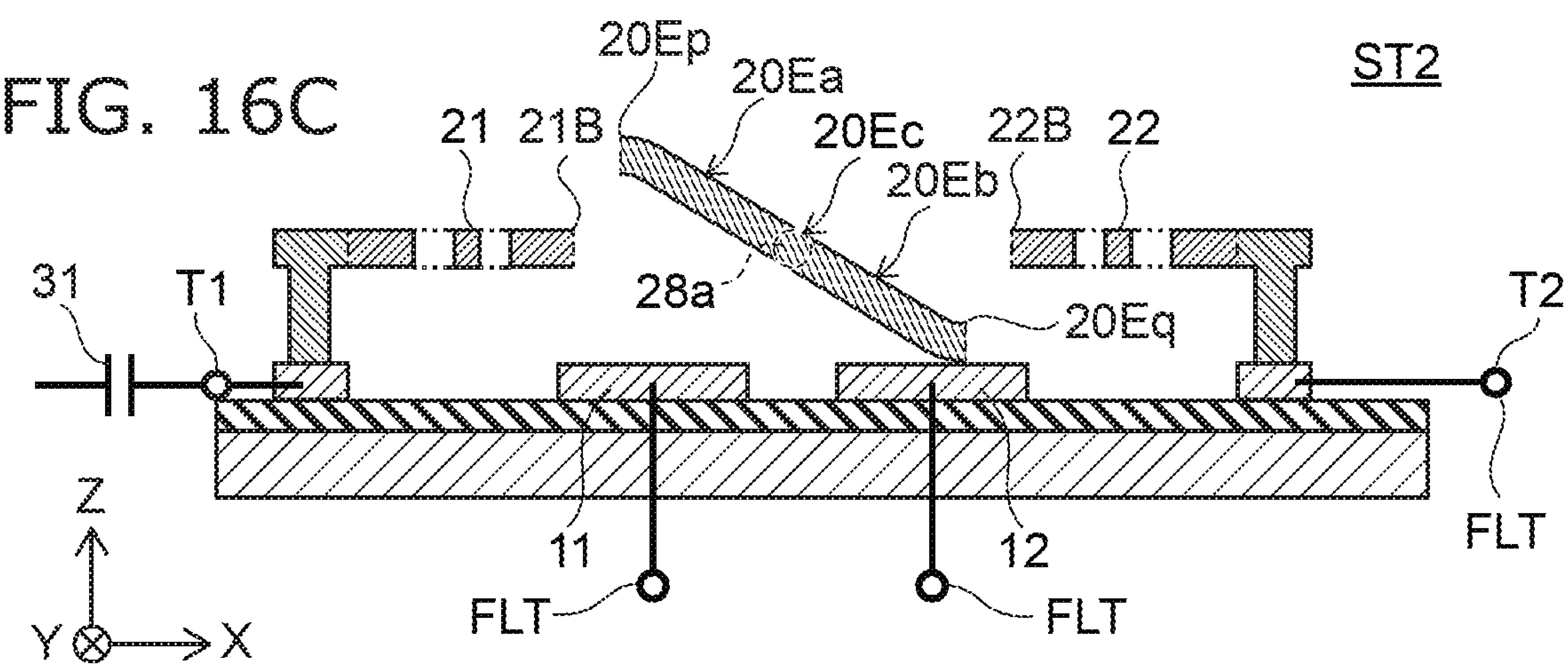


FIG. 17A

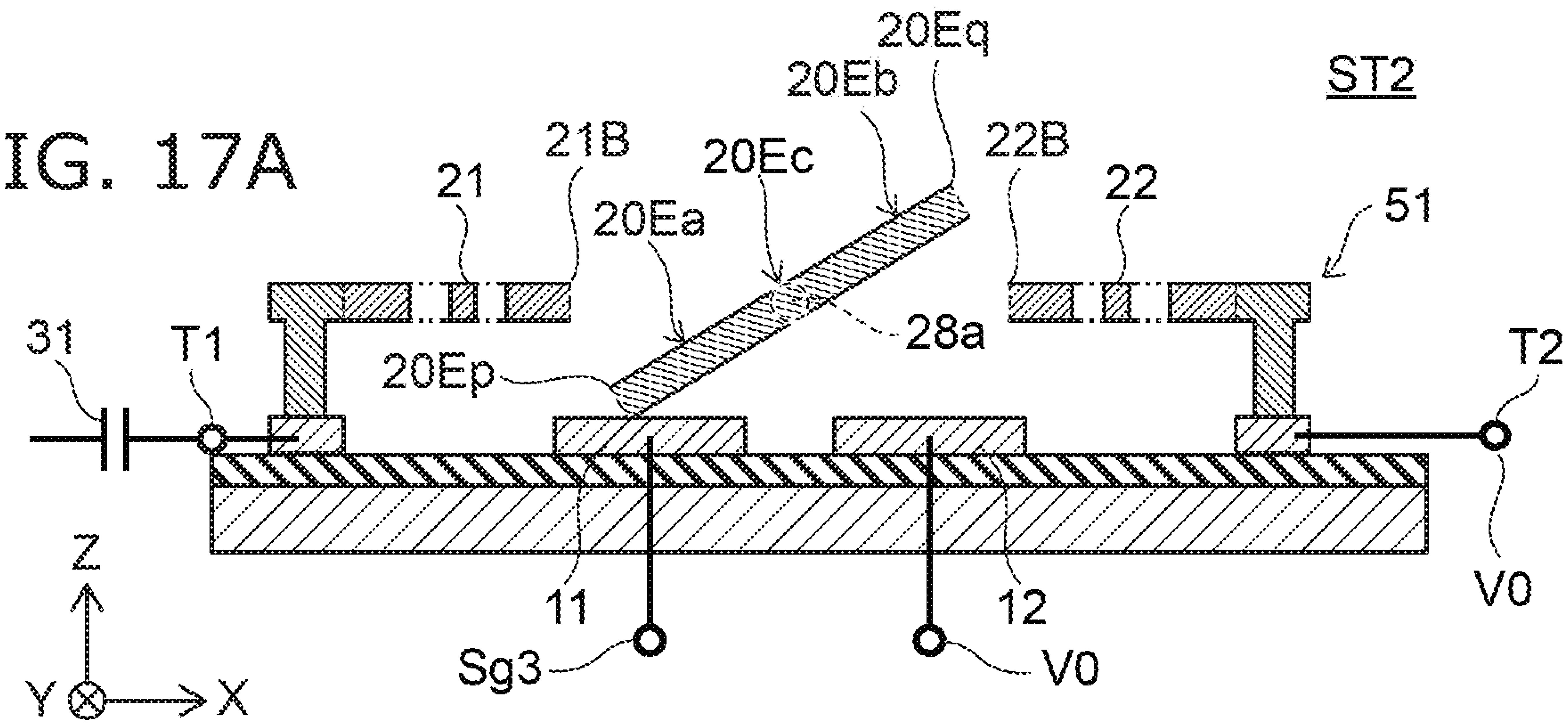
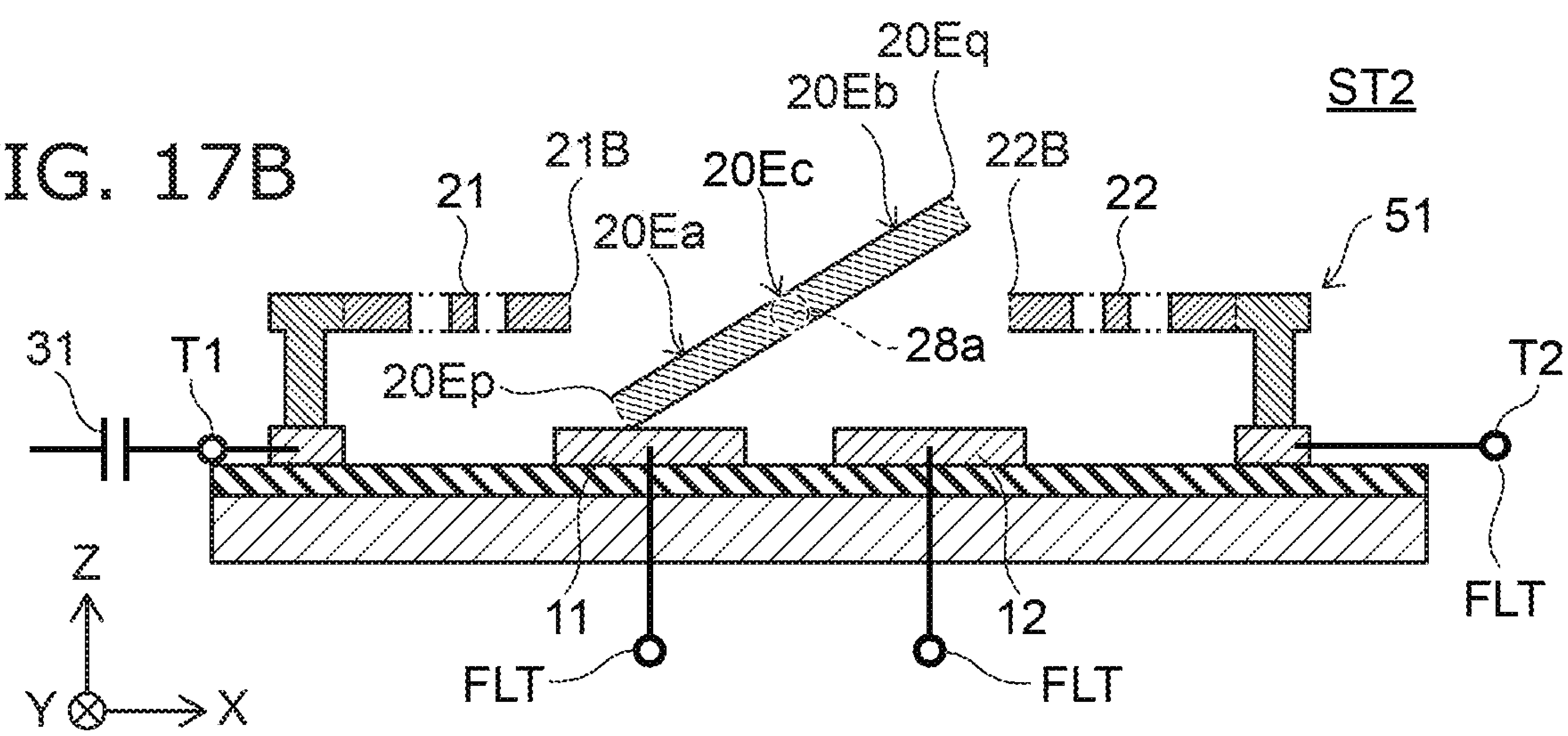
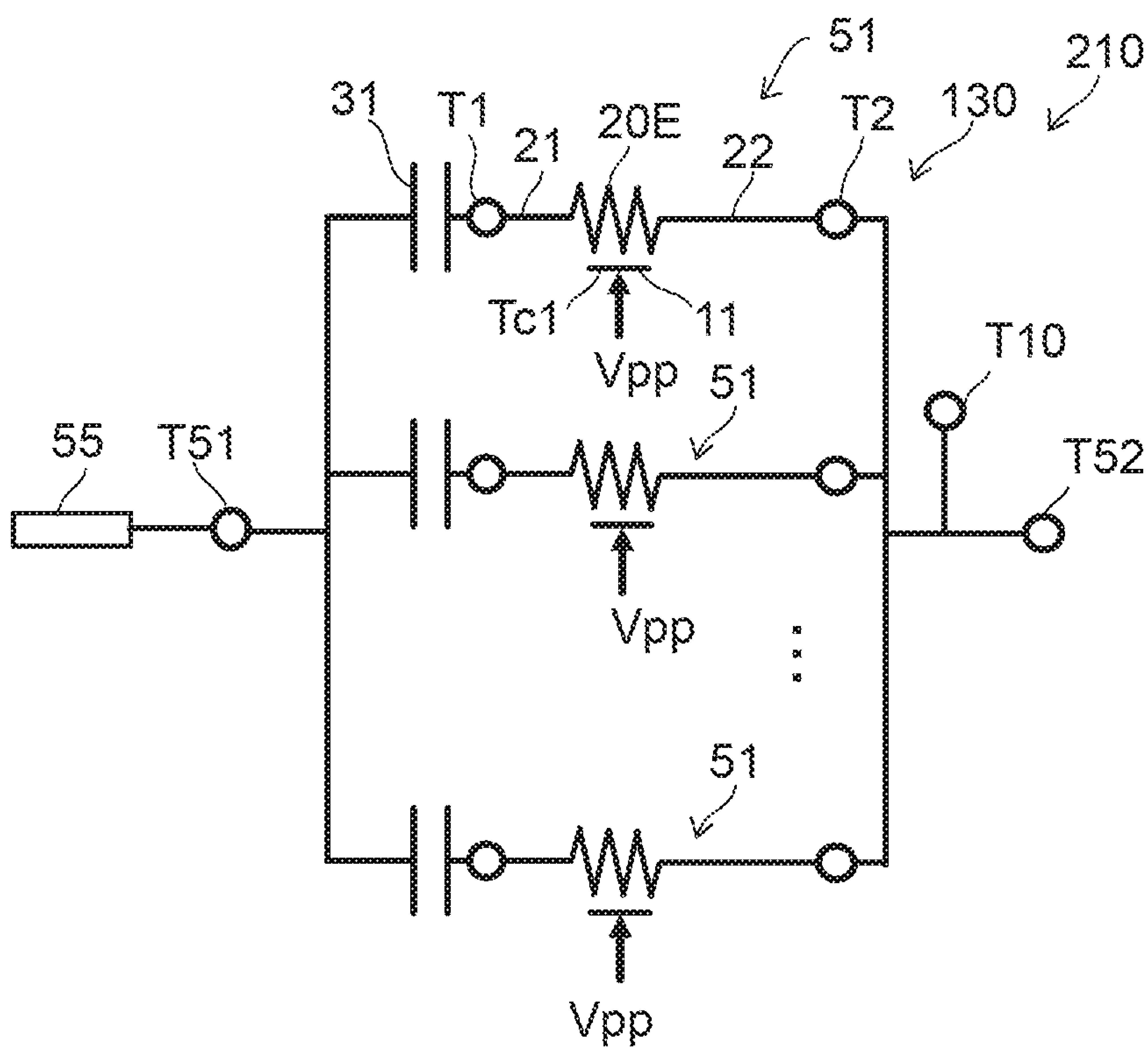


FIG. 17B

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210
31
T1
21
20E
22
T2
130
Tc1
11
Vpp
T10
51
55
T51
T52
Vpp
51
Vpp

FIG. 18

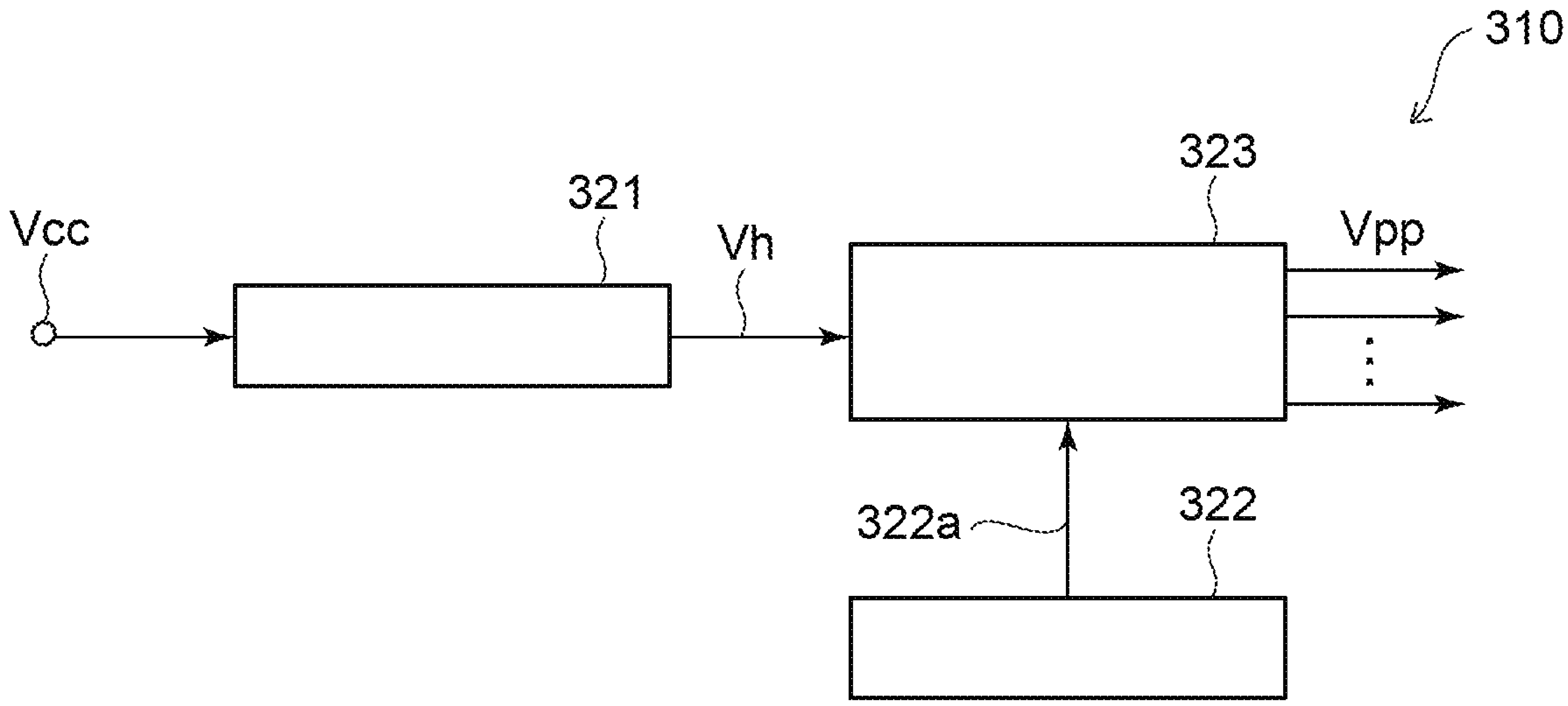
310
Vcc
321
Vh
323
Vpp
322a
322

FIG. 19

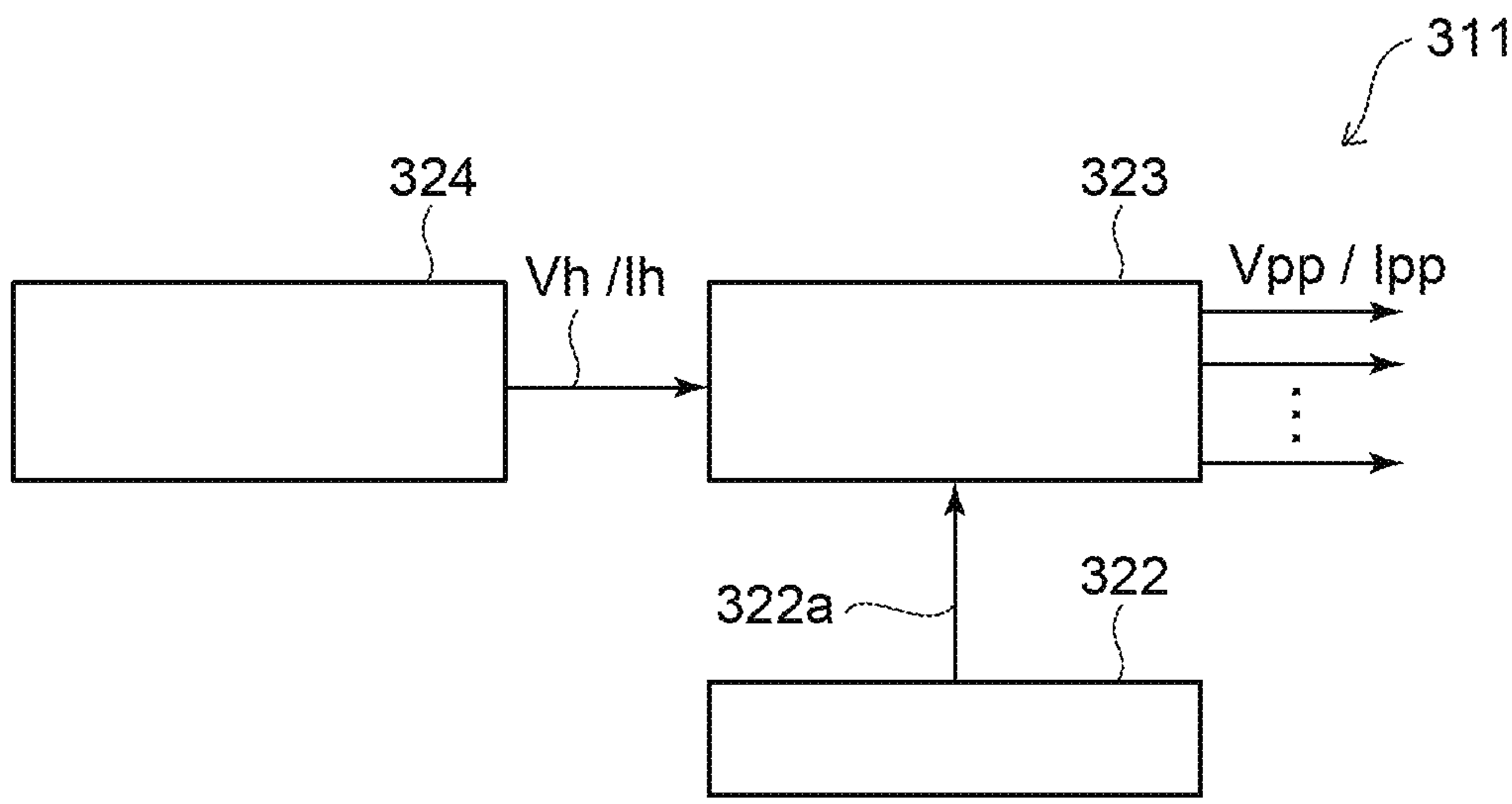
311
324
Vh /Ih
323
Vpp / Ipp
322a
322

FIG. 20

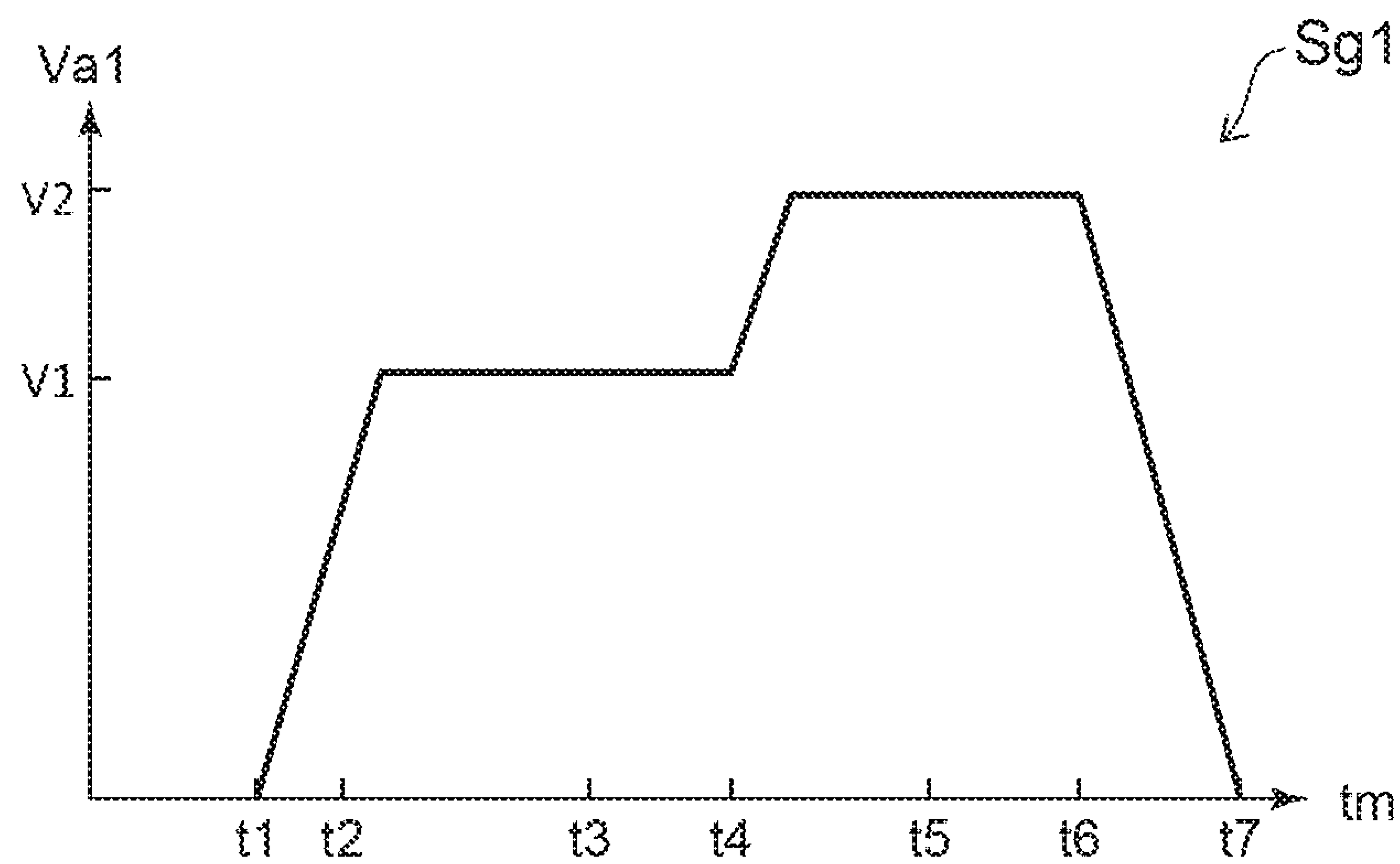

FIG. 21A

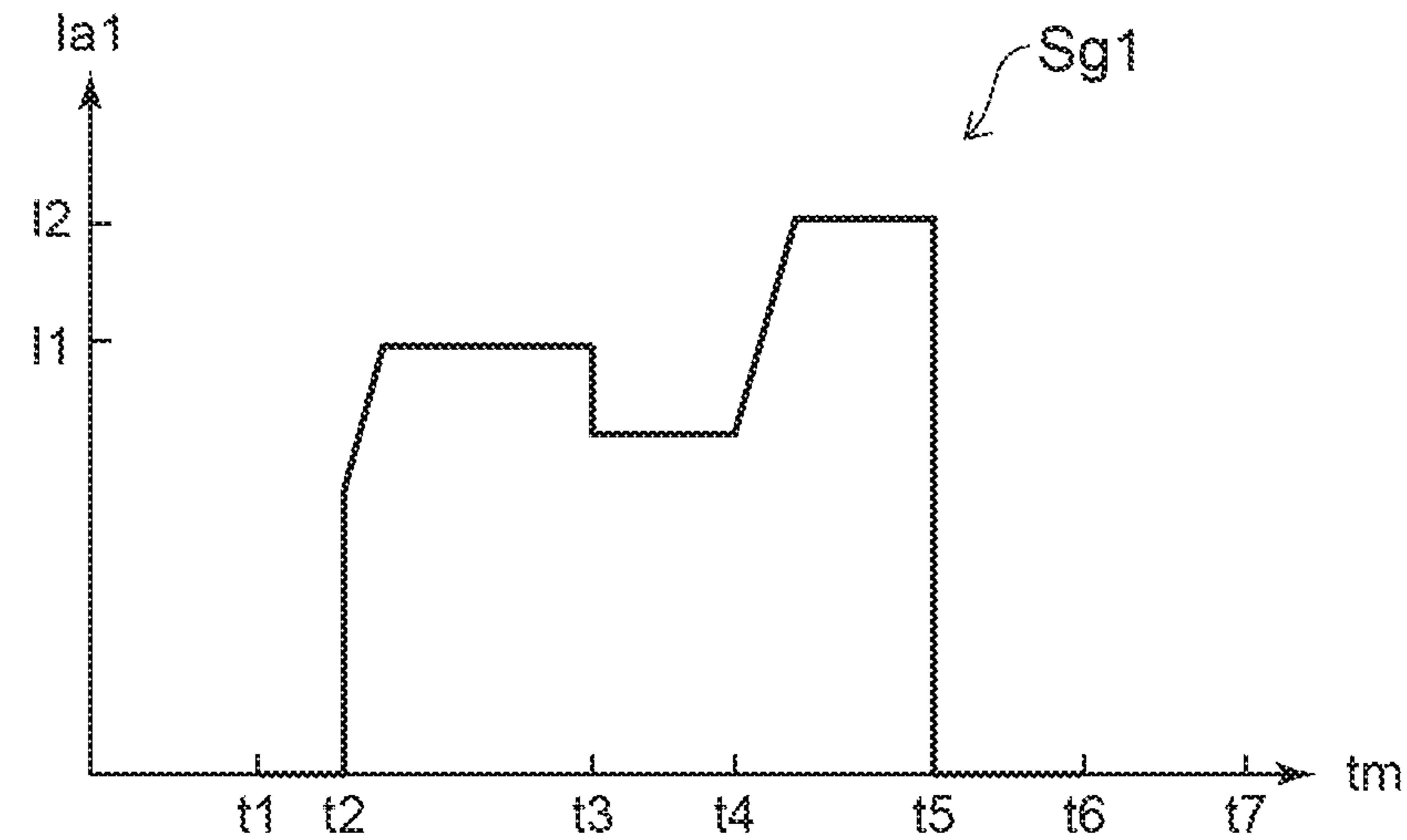

FIG. 21B

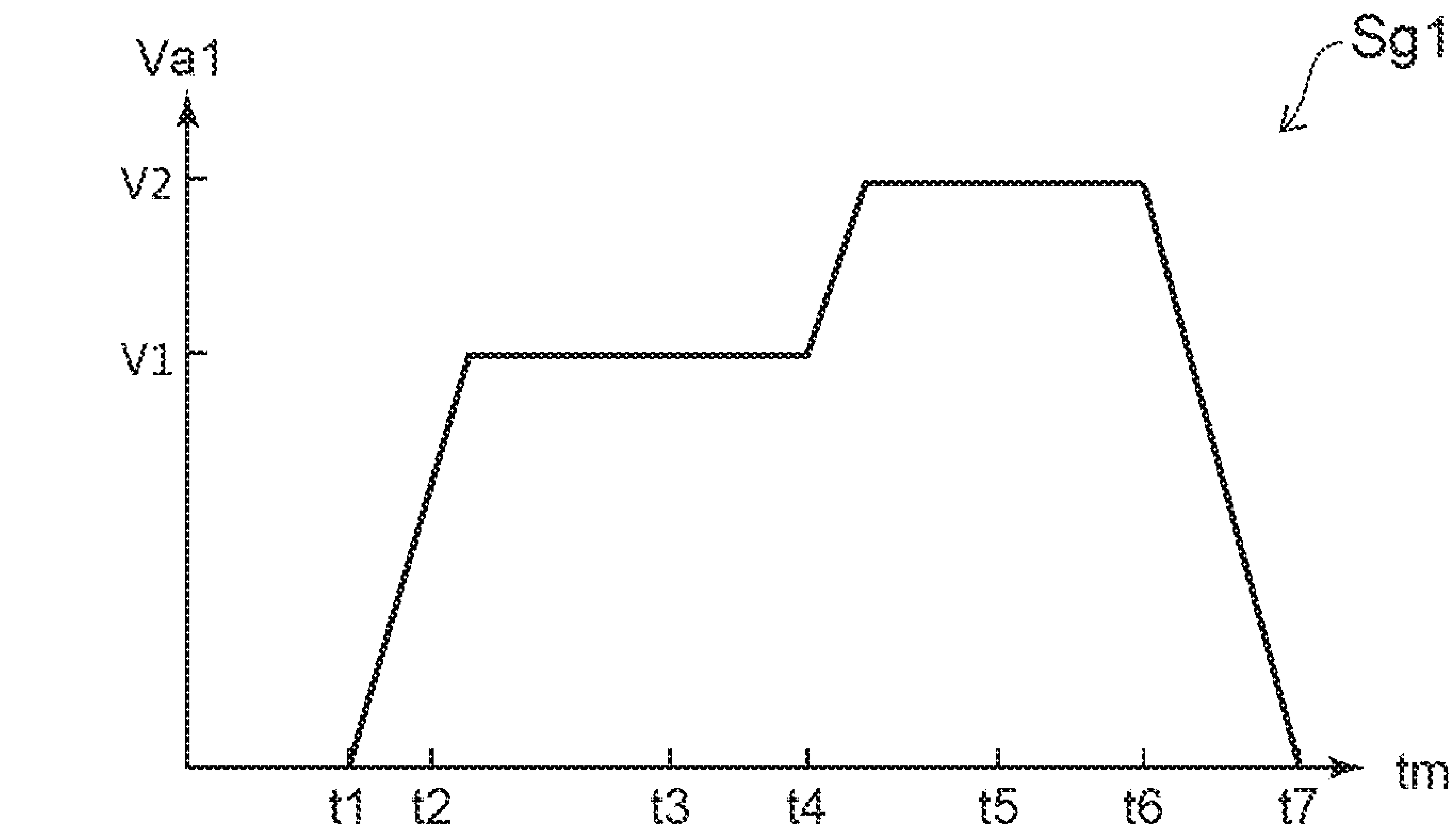

FIG. 22A

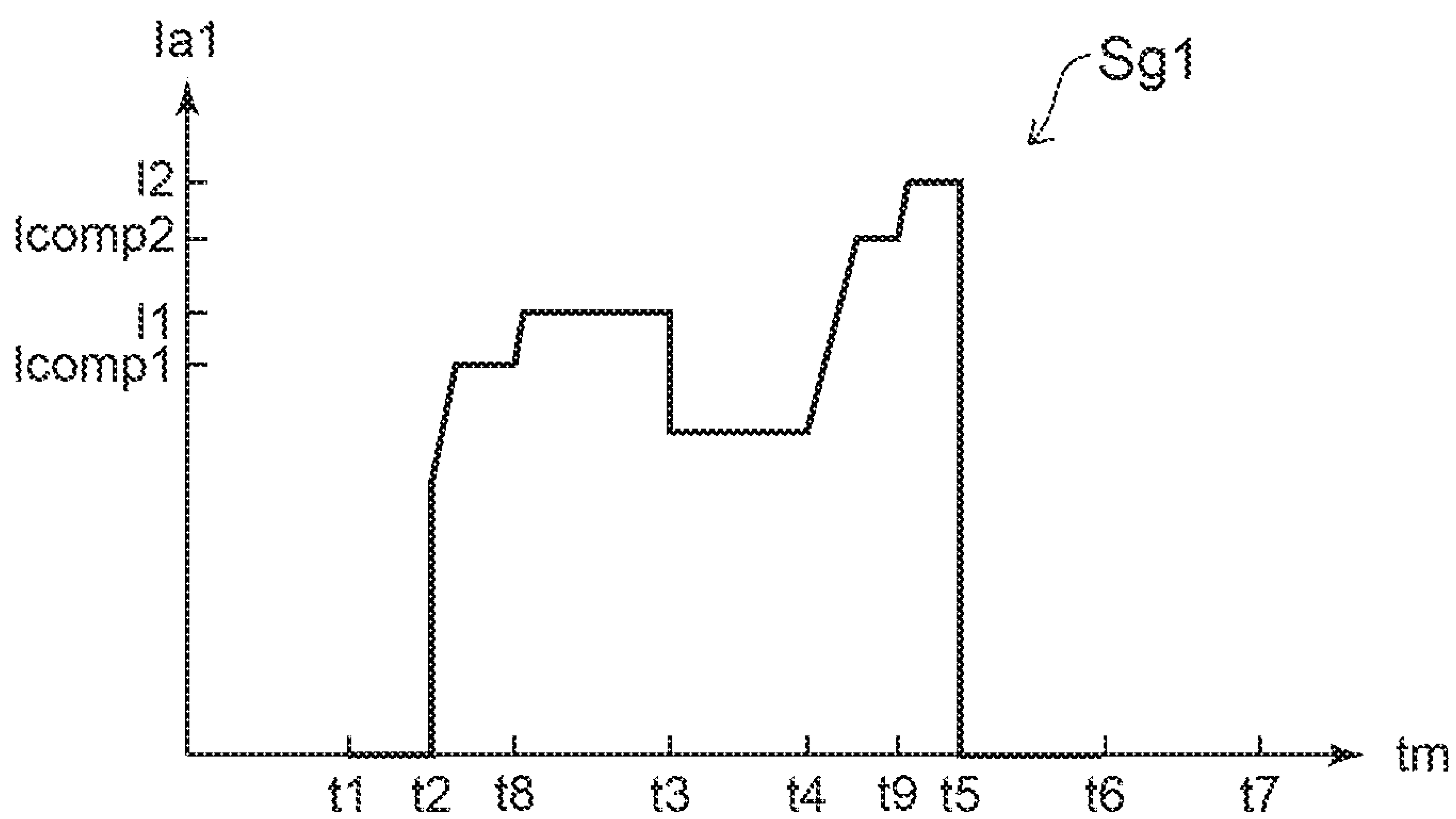

FIG. 22B

MEMS ELEMENT FUSE-LIKE ELECTRICAL CIRCUIT INTERRUPTER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2019-222325, filed on Dec. 9, 2019; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments of the invention generally relate to a MEMS element and an electrical circuit.

BACKGROUND

For example, a MEMS (Micro Electro Mechanical Systems) element is used in a switch or the like. A stable operation of the MEMS element is desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A and FIG. **1**B are schematic views illustrating a MEMS element according to a first embodiment;

FIG. **2**A to FIG. **2**C are schematic cross-sectional views illustrating the MEMS element according to the first embodiment;

FIG. **3**A and FIG. **3**B are schematic cross-sectional views illustrating the MEMS element according to the first embodiment;

FIG. **4**A and FIG. **4**B are schematic plan views illustrating a MEMS element according to the first embodiment;

FIG. **5**A and FIG. **5**B are schematic plan views illustrating a MEMS element according to the first embodiment;

FIG. **6**A and FIG. **6**B are schematic plan views illustrating a MEMS element according to the first embodiment;

FIG. **7**A and FIG. **7**B are schematic plan views illustrating a MEMS element according to the first embodiment;

FIG. **8**A to FIG. **8**C are schematic plan views illustrating a MEMS element according to the first embodiment;

FIG. **9** is a schematic cross-sectional view illustrating a MEMS element according to the first embodiment;

FIG. **10**A and FIG. **10**B are schematic views illustrating a MEMS element according to a second embodiment;

FIG. **11**A to FIG. **11**C are schematic cross-sectional views illustrating the MEMS element according to the second embodiment;

FIG. **12**A and FIG. **12**B are schematic cross-sectional views illustrating the MEMS element according to the second embodiment;

FIG. **13** is a schematic cross-sectional view illustrating a MEMS element according to the second embodiment;

FIG. **14**A and FIG. **14**B are schematic views illustrating a MEMS element according to the second embodiment;

FIG. **15**A to FIG. **15**C are schematic cross-sectional views illustrating the MEMS element according to the second embodiment;

FIG. **16**A to FIG. **16**C are schematic cross-sectional views illustrating the MEMS element according to the second embodiment;

FIG. **17**A and FIG. **17**B are schematic cross-sectional views illustrating the MEMS element according to the embodiment;

FIG. **18** is a schematic view illustrating a MEMS element according to a third embodiment;

FIG. **19** is a schematic view illustrating a control circuit used in the MEMS element according to the embodiment;

FIG. **20** is a schematic view illustrating a control circuit used in the MEMS element according to the embodiment;

FIG. **21**A and FIG. **21**B are schematic views illustrating an operation relating to the MEMS element according to the first embodiment; and

FIG. **22**A and FIG. **22**B are schematic views illustrating an operation relating to the MEMS element according to the first embodiment.

DETAILED DESCRIPTION

According to one embodiment, a MEMS element includes a first member, and an element part. The element part includes a first fixed electrode fixed to the first member, a first movable electrode facing the first fixed electrode, a first conductive member electrically connected to the first movable electrode, and a second conductive member electrically connected to the first movable electrode. The first conductive member and the second conductive member support the first movable electrode to be separated from the first fixed electrode in a first state before a first electrical signal is applied between the second conductive member and the first fixed electrode. The first conductive member and the second conductive member are in a broken state in a second state after the first electrical signal is applied between the second conductive member and the first fixed electrode.

According to one embodiment, an electrical circuit includes the MEMS element described above, and an electrical element electrically connected to the MEMS element. The electrical element includes at least one selected from the group consisting of a resistance, a capacitance element, an inductor element, a diode, and a transistor.

Various embodiments are described below with reference to the accompanying drawings.

The drawings are schematic and conceptual; and the relationships between the thickness and width of portions, the proportions of sizes among portions, etc., are not necessarily the same as the actual values. The dimensions and proportions may be illustrated differently among drawings, even for identical portions.

In the specification and drawings, components similar to those described previously or illustrated in an antecedent drawing are marked with like reference numerals, and a detailed description is omitted as appropriate.

First Embodiment

FIG. **1**A and FIG. **1**B are schematic views illustrating a MEMS element according to a first embodiment.

FIG. **1**A is a plan view as viewed along arrow AR**1** of FIG. **1**B. FIG. **1**B is a line A**1**-A**2** cross-sectional view of FIG. **1**A.

As shown in FIG. **1**B, the MEMS element **110** according to the embodiment includes a first member **41** and an element part **51**. A first member **41** is, for example, a base body. In the example, the first member **41** includes a substrate **41***s* and an insulating layer **41***i*. The substrate **415** is, for example, a silicon substrate. The substrate **41***s* may include a control element such as a transistor, etc. The insulating layer **41***i* is provided on the substrate **415**. For example, the element part **51** is provided on the insulating layer **41***i*. In the embodiment, the first member **41** may include interconnects, etc. (not illustrated). For example, the interconnects electrically connect the element part **51** and the substrate **41**_s_. The interconnects may include contact vias.

As shown in FIG. **1**A and FIG. **1**B, the element part **51** includes a first fixed electrode **11**, a first movable electrode **20**E, a first conductive member **21**, and a second conductive member **22**. The first fixed electrode **11** is fixed to the first member **41**. For example, the first fixed electrode **11** is provided on the insulating layer **41**_i_.

The first movable electrode **20**E faces the first fixed electrode **11**. The first conductive member **21** is electrically connected to the first movable electrode **20**E. The second conductive member **22** is electrically connected to the first movable electrode **20**E.

As described below, for example, a first electrical signal Sg**1** (referring to FIG. **1**B) can be applied between the second conductive member **22** and the first fixed electrode **11**. The state before the first electrical signal Sg**1** is applied is taken to be a first state (e.g., an initial state). FIG. **1**A and FIG. **1**B illustrate the first state.

As shown in FIG. **1**B, the first conductive member **21** and the second conductive member **22** support the first movable electrode **20**E to be separated from the first fixed electrode **11** in the first state. For example, a first gap g**1** is between the first fixed electrode **11** and the first movable electrode **20**E in the first state.

For example, a first supporter **21**S and a second supporter **22**S are provided. The first supporter **21**S and the second supporter **22**S are fixed to the first member **41**. The first supporter **21**S and the second supporter **22**S are conductive.

One end of the first conductive member **21** is connected to the first supporter **21**S. The first conductive member **21** is supported by the first supporter **21**S. The other end of the first conductive member **21** is connected to the first movable electrode **20**E. One end of the second conductive member **22** is connected to the second supporter **22**S. The second conductive member **22** is supported by the second supporter **22**S. The other end of the second conductive member **22** is connected to the first movable electrode **20**E. In the example, the first movable electrode **20**E is between the first supporter **21**S and the second supporter **22**S. The first conductive member **21** is between the first supporter **21**S and the first movable electrode **20**E. In the example, the second conductive member **22** is between the first movable electrode **20**E and the second supporter **22**S.

As shown in FIG. **1**A, for example, the first conductive member **21** and the second conductive member **22** are fine wire-shaped. In the example, the first conductive member **21** and the second conductive member **22** have meandering structures. For example, the first conductive member **21** and the second conductive member **22** are spring members.

As shown in FIG. **1**A, for example, the widths of the first and second conductive members **21** and **22** are less than a width W**20** of the first movable electrode **20**E. The first conductive member **21** and the second conductive member **22** deform more easily than the first movable electrode **20**E.

The direction from the first fixed electrode **11** toward the first movable electrode **20**E is taken as a Z-axis direction. One direction perpendicular to the Z-axis direction is taken as an X-axis direction. A direction perpendicular to the Z-axis direction and the X-axis direction is taken as a Y-axis direction.

In the example, the direction from the first conductive member **21** toward the second conductive member **22** is along the X-axis direction. The distance (the length in the Z-axis direction) between the first fixed electrode **11** and the first movable electrode **20**E is changeable according to the potential difference between the first fixed electrode **11** and the first movable electrode **20**E. The first movable electrode **20**E is displaceable when referenced to the first fixed electrode **11**.

A first terminal T**1** and a second terminal T**2** may be provided as shown in FIG. **1**B. The first terminal T**1** is electrically connected to the first conductive member **21**. The second terminal T**2** is electrically connected to the second conductive member **22**. For example, a current can flow between the first terminal T**1** and the second terminal T**2** in the first state. At this time, the MEMS element **110** is in a conducting state (e.g., an on-state). As described below, the first conductive member **21** and the second conductive member **22** can be broken. In such a case, a current does not flow between the first terminal T**1** and the second terminal T**2**. At this time, the MEMS element **110** is in a nonconducting state (e.g., an off-state).

In the on-state, for example, a current can flow in a first current path **21**_cp_ including the first conductive member **21** and the first movable electrode **20**E (referring to FIG. **1**A). In the on-state, for example, a current can flow in a second current path **22**_cp_ including the second conductive member **22** and the first movable electrode **20**E (referring to FIG. **1**A).

The MEMS element **110** can function as a normally-on switch element.

The element part **51** may include a first capacitance element **31**. For example, the first capacitance element **31** is electrically connected to the first conductive member **21**. In the example, the first capacitance element **31** is electrically connected to the first terminal T**1**. The electrical connection to the first capacitance element **31** can be controlled by controlling the on-state or the off-state of the element part **51**.

As shown in FIG. **1**B, for example, a controller **70** may be provided. For example, the controller **70** is electrically connected to a first control terminal Tc**1** and the second terminal T**2**. The first control terminal Tc**1** is electrically connected to the first fixed electrode **11**. The first electrical signal Sg**1** can be applied between the second conductive member **22** and the first fixed electrode **11** by the controller **70**. The first electrical signal Sg**1** includes at least one of a voltage signal or a current signal.

For example, the potential of the second conductive member **22** (e.g., the potential of the second terminal T**2**) is fixed, and the potential of the first fixed electrode **11** is controllable by the controller **70**. In the embodiment, the potential of the first fixed electrode **11** may be substantially fixed, and the potential of the second conductive member **22** may be controllable by the controller **70**. Hereinbelow, one example will be described in which the potential of the second conductive member **22** (e.g., the potential of the second terminal T**2**) is fixed. In such a case, the potential of the first fixed electrode **11** is controlled by the controller **70**. The polarity of the potential difference between the second conductive member **22** and the first fixed electrode **11** is arbitrary.

In the first state, the potential of the first movable electrode **20**E is substantially equal to the potential of the second conductive member **22**. The potential difference between the first fixed electrode **11** and the first movable electrode **20**E is changed by changing the potential of the first fixed electrode **11**. For example, the distance between the first movable electrode **20**E and the first fixed electrode **11** decreases as the potential difference increases. For example, this is based on an electrostatic force. When the potential difference becomes large, the first movable electrode **20**E contacts the first fixed electrode **11**, and a current can flow in the conductive member via the first movable electrode **20**E and the first fixed electrode **11**. The conductive member can be broken thereby. The first state before breaking and the second state after breaking can be formed thereby. The phenomenon of the first movable electrode **20**E and the first fixed electrode **11** contacting is called "pull-in" or "pull-down". The voltage that generates "pull-in" or "pull-down" is called the "pull-in voltage" or the "pull-down voltage".

For example, the element part **51** of the MEMS element **110** can function as a OTP (One Time Programmable) element.

For example, the rigidity of the first conductive member **21** may be different from the rigidity of the second conductive member **22**. For example, the rigidity of the first conductive member **21** may be less than the rigidity of the second conductive member **22**. For example, the first conductive member **21** and the second conductive member **22** are mutually-asymmetric. For example, by such a configuration, the first movable electrode **20**E easily changes to a tilted state when the first movable electrode **20**E approaches the first fixed electrode **11**. The first movable electrode **20**E may approach the first fixed electrode **11** in a tilted state.

An example of a transition from the first state to the second state will now be described.

FIG. **2**A to FIG. **2**C, FIG. **3**A and FIG. **3**B are schematic cross-sectional views illustrating the MEMS element according to the first embodiment.

These drawings illustrate the change of the element part **51** when the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. As described above, the first electrical signal Sg**1** is supplied by the controller **70**.

In the first state ST**1** shown in FIG. **2**A, the first electrical signal Sg**1** is not applied between the second conductive member **22** and the first fixed electrode **11**. For example, the second conductive member **22** and the first fixed electrode **11** are in a floating state FLT. At this time, the first movable electrode **20**E is separated from the first fixed electrode **11**. In such a first state ST**1**, a current can flow between the first terminal T**1** and the second terminal T**2**. The element part **51** is in the conducting state (the on-state) in the first state ST**1**. In the first state ST**1**, the potential difference between the second conductive member **22** and the first fixed electrode **11** may be less than the pull-in voltage.

As shown in FIG. **2**B, for example, the second terminal T**2** (the second conductive member **22**) is set to a ground potential V**0**, and the first electrical signal Sg**1** is applied to the first fixed electrode **11**. Thereby, the first movable electrode **20**E is caused to approach the first fixed electrode **11**. For example, the first movable electrode **20**E tilts easily when the first conductive member **21** and the second conductive member **22** are asymmetric. For example, compared to an end portion **20**Eq at the second conductive member **22** side of the first movable electrode **20**E, an end portion **20**Ep at the first conductive member **21** side of the first movable electrode **20**E approaches the first fixed electrode **11**. An electric field concentrates at the end portion **20**Ep at the first conductive member **21** side of the first movable electrode **20**E and an end portion **21***p* at the first movable electrode **20**E side of the first conductive member **21**. For example, the end portion **21***p* contacts the first fixed electrode **11**. For example, the end portion **20**Ep contacts the first fixed electrode **11**. Thereby, the temperature easily rises locally at the end portions **20**Ep and **21***p*. For example, the rise of the temperature is due to Joule heat.

The first conductive member **21** breaks when the temperature of at least one of the end portion **20**Ep or the end portion **21***p* rises locally. As shown in FIG. **2**B, a break portion **21**B occurs in the first conductive member **21**. The first conductive member **21** is divided at the break portion **21**B.

For example, as shown in FIG. **1**A, a portion of the first conductive member **21** may overlap the first fixed electrode **11** in the Z-axis direction. For example, when a portion of the first conductive member **21** overlaps the first fixed electrode **11** in the Z-axis direction, the portion (the end portion **21***p*) of the first conductive member **21** easily contacts the first fixed electrode **11** when the first movable electrode **20**E approaches the first fixed electrode **11**. For example, a current locally flows between the first fixed electrode **11** and the portion (the end portion **21***p*) of the first conductive member **21**. The first conductive member **21** is broken more stably by the current concentrating at the portion (the end portion **21***p*) of the first conductive member **21**. For example, the mechanical rigidity of the first conductive member **21** is less than the mechanical rigidity of the first movable electrode **20**E. Thereby, the end portion **21***p* easily contacts the first fixed electrode **11**.

As shown in FIG. **2**C, the broken first conductive member **21** may approach the state of FIG. **2**A. For example, this is due to the restoring force due to the elasticity of the first conductive member **21**. As shown in FIG. **2**C, the end portion **20**Ep of the first movable electrode **20**E is separated from the first conductive member **21**.

As shown in FIG. **3**A, substantially the entire first movable electrode **20**E may contact the first fixed electrode **11** when the application of the first electrical signal Sg**1** is continued. This state is, for example, the pull-down state. When the first movable electrode **20**E contacts the first fixed electrode **11**, there are cases where the first movable electrode **20**E is adhered to the first fixed electrode **11**, and the first movable electrode **20**E substantially does not separate from the first fixed electrode **11**.

As shown in FIG. **3**A, when the application of the first electrical signal Sg**1** is continued, the temperature of the second conductive member **22** rises, and the second conductive member **22** breaks. For example, the rise of the temperature is due to Joule heat. A break portion **22**B occurs. The second conductive member **22** is divided at the break portion **22**B. For example, the break portion **22**B is formed at the vicinity of the end portion of the second conductive member **22** at the first movable electrode **20**E side. The application of the first electrical signal Sg**1** ends.

Subsequently, as shown in FIG. **3**B, the broken second conductive member **22** may approach the state of FIG. **2**A. For example, this is due to the restoring force due to the elasticity of the second conductive member **22**. As shown in FIG. **3**B, the end portion **20**Eq of the first movable electrode **20**E is separated from the second conductive member **22**.

A second state ST**2** shown in FIG. **3**B is a state after the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. For example, in the second state ST**2**, the first fixed electrode **11** is in, for example, the floating state FLT. The broken states of the first and second conductive members **21** and **22** continue even after the application of the first electrical signal Sg**1** has ended. A current does not flow between the first terminal T**1** and the second terminal T**2** in the second state ST**2**. The element part **51** is in the nonconducting state (the off-state) in the second state ST**2**. For example, in the second state ST**2**, the second conductive member **22** is in, for example, the floating state FLT. Or, in the second state

ST2, the potential of the second conductive member **22** may have the potential of a circuit connected to the second conductive member **22**.

Thus, in the embodiment, both the first conductive member **21** and the second conductive member **22** are in a broken state in the second state ST2 after the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. For, example, the first conductive member **21** is in a first broken state in the second broken state in the second state ST**2** and the second conductive member **22** is in the second broken state in the second state ST**2**. The current that flows between the first terminal T**1** and the second terminal T**2** can be stably blocked thereby.

A reference example may be considered in which one of the first conductive member **21** or the second conductive member **22** is broken. For example, in a first reference example, the second conductive member **22** side of the first movable electrode **20**E contacts the first fixed electrode **11** when the first electrical signal Sg**1** is applied to the first fixed electrode **11**. In such a case, the second conductive member **22** is broken by the Joule heat due to the current of the first electrical signal Sg**1**. On the other hand, the other end (the first terminal T**1**) of the first conductive member **21** is floating. Therefore, when the first electrical signal Sg**1** is applied to the first fixed electrode **11**, a current does not flow in the first conductive member **21**, and the first conductive member **21** is not broken. In such a first reference example as well, the current that flows between the first terminal T**1** and the second terminal T**2** can be blocked.

In the first reference example after the second conductive member **22** is broken, the first terminal T**1** is electrically connected to the first fixed electrode **11** via the first conductive member **21** and the first movable electrode **20**E. For example, when a transistor that controls the application of the first electrical signal Sg**1** to the first fixed electrode **11** or the like is connected to the first fixed electrode **11**, the parasitic capacitance of the transistor remains even after the application of the first electrical signal Sg**1** is ended. The parasitic capacitance of the transistor affects the capacitance of the first terminal T**1**. In the first reference example, such an unnecessary capacitance remains in the element part **51**. The remaining capacitance easily causes unstable electrical characteristics of the off-state of the element part **51** functioning as a switch. For example, when the signal of the circuit in which the element part **51** is embedded has a high frequency, the remaining capacitance makes the characteristics of the element part **51** unstable.

In the embodiment, the first conductive member **21** and the second conductive member **22** are in a broken state in the second state ST**2**. Therefore, the first terminal T**1** is separated from the first fixed electrode **11** and the parasitic capacitance of the transistor. The electrical characteristics of the element part **51** in the off-state are stabilized thereby. Stable characteristics can be maintained even for high frequency switching. According to the embodiment, a MEMS element can be provided in which a stable operation is possible.

In the embodiment, for example, the first conductive member **21** breaks when the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. Continuing, the second conductive member **22** also is broken by continuing the application of the first electrical signal Sg**1**. Or, the application of the first electrical signal Sg**1** can be ended after the first conductive member **21** has broken and before the second conductive member **22** has broken. However, the first electrical signal Sg**1** may not be ended partway because the second conductive member **22** can be broken by continuing the application of the first electrical signal Sg**1**.

In the description recited above, the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. In the embodiment, the first electrical signal Sg**1** may be applied between the first conductive member **21** and the first fixed electrode **11**. In such a case, the first movable electrode **20**E is caused to tilt so that the distance between the first fixed electrode **11** and the end portion at the second conductive member **22** side of the first movable electrode **20**E is less than the distance between the first fixed electrode **11** and the end portion at the first conductive member **21** side of the first movable electrode **20**E. Because the first movable electrode **20**E approaches the first fixed electrode **11** in the tilted state, both the first conductive member **21** and the second conductive member **22** are in a broken state in the second state ST**2** after the first electrical signal Sg**1** is applied.

As recited above, both of two conductive members can easily be broken by the first movable electrode **20**E approaching the first fixed electrode **11** in the tilted state. For example, when one of the first conductive member **21** or the second conductive member **22** will become proximate to the first fixed electrode **11**, the first electrical signal Sg**1** is applied between the first fixed electrode **11** and the other of the first conductive member **21** or the second conductive member **22**. The conductive member to which the first electrical signal Sg**1** is applied may be selected to match the tilt direction.

In the embodiment, for example, the first movable electrode **20**E is tilted more easily by setting the mechanical rigidities of the two conductive members to be asymmetric. For example, the distance between the first movable electrode **20**E and the first fixed electrode **11** in the first state ST**1** may be different between the first conductive member **21** side and the second conductive member **22** side. Thereby, it is easier for the first movable electrode **20**E to approach the first fixed electrode **11** in a state in which the distance between the first movable electrode **20**E and the first fixed electrode **11** is nonuniform. For example, a protrusion or the like may be provided in the lower surface of the end portion **20**Ep of the first movable electrode **20**E or the upper surface of an end portion **11***p* of the first fixed electrode **11**. Even in such a case, the first conductive member **21** and the second conductive member **22** break more easily in the second state ST**2**. For example, the surface area of the portion at which the first movable electrode **20**E and the first fixed electrode **11** face each other may be different between the first conductive member **21** side and the second conductive member **22** side.

As shown in FIG. **1**B, for example, the direction from the first fixed electrode **11** toward the first movable electrode **20**E is taken as a first direction. The first direction corresponds to the Z-axis direction. At least one of a portion of the first conductive member **21** or a portion of the second conductive member **22** may overlap the first fixed electrode **11** in the first direction. When a portion of the first conductive member **21** overlaps the first fixed electrode **11**, a large current flows locally between the portion (e.g., the end portion **21***p* illustrated in FIG. **2**B) of the first conductive member **21** and the end portion **11***p* of the first fixed electrode **11** (referring to FIG. **1**B). The first conductive member **21** is broken more easily thereby. On the other hand, when a portion of the second conductive member **22** overlaps the first fixed electrode **11**, a large current flows locally between the end portion of the portion of the second conductive member **22** and the end portion **11**p of the first fixed electrode **11**. The second conductive member **22** is broken more easily thereby.

In the embodiment as described above, for example, a current can flow between the first movable electrode **20**E and the first fixed electrode **11** when the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**. For example, the first movable electrode **20**E contacts the first fixed electrode **11** when the first electrical signal Sg**1** is applied between the second conductive member **22** and the first fixed electrode **11**.

Several examples of configurations in which the first conductive member **21** and the second conductive member **22** break more easily will now be described.

FIG. **4**A and FIG. **4**B are schematic plan views illustrating a MEMS element according to the first embodiment.

These drawings illustrate a portion of the MEMS element **111** according to the embodiment. FIG. **4**A illustrates the first conductive member **21**. FIG. **4**B illustrates the second conductive member **22**.

As shown in FIG. **4**A, the first conductive member **21** has a first length along the first current path **21**cp including the first conductive member **21** and the first movable electrode **20**E. The first length corresponds to the sum of lengths L**11** to L**17**.

As shown in FIG. **4**B, the second conductive member **22** has a second length along the second current path **22**cp including the second conductive member **22** and the first movable electrode **20**E. The second length corresponds to the sum of lengths L**21** to L**27**.

In the example, the second length is less than the first length. In such a case, the rigidity of the first conductive member **21** is less than the rigidity of the second conductive member **22**. The characteristics of the first conductive member **21** and the characteristics of the second conductive member **22** are made asymmetric thereby.

FIG. **5**A and FIG. **5**B are schematic plan views illustrating a MEMS element according to the first embodiment.

These drawings illustrate a portion of the MEMS element **112** according to the embodiment. FIG. **5**A illustrates the first conductive member **21**. FIG. **5**B illustrates the second conductive member **22**.

As shown in FIG. **5**A, the first conductive member **21** has a first width W**1**. The first width W**1** is the length of the first conductive member **21** in a direction Dp**1** perpendicular to the first current path **21**cp including the first conductive member **21** and the first movable electrode **20**E. The first width W**1** may be the thickness (the length along the Z-axis direction).

As shown in FIG. **5**B, the second conductive member **22** has a second width W**2**. The second width W**2** is the length of the second conductive member **22** in a direction Dp**2** perpendicular to the second current path **22**cp including the second conductive member **22** and the first movable electrode **20**E. The second width W**2** may be the thickness (the length along the Z-axis direction).

In the example, the second width W**2** is greater than the first width W**1**. In such a case, the rigidity of the first conductive member **21** is less than the rigidity of the second conductive member **22**. Thereby, the characteristics of the first conductive member **21** are asymmetric with the characteristics of the second conductive member **22**.

Thus, the second conductive member **22** may have at least one of the second length that is less than the first length, or the second width W**2** that is greater than the first width W**1**. For example, the rigidity of the first conductive member **21** is less than the rigidity of the second conductive member **22**. The characteristics of the first conductive member **21** are asymmetric with the characteristics of the second conductive member **22**.

In the embodiment, the melting point of at least a portion of the first conductive member **21** may be different from the melting point of at least a portion of the second conductive member **22**. In the embodiment, the electrical resistance of the first conductive member **21** may be different from the electrical resistance of the second conductive member **22**.

FIG. **6**A and FIG. **6**B are schematic plan views illustrating a MEMS element according to the first embodiment.

These drawings illustrate a portion of the MEMS element **113** according to the embodiment. FIG. **6**A illustrates the first conductive member **21**. FIG. **6**B illustrates the second conductive member **22**.

As shown in FIG. **6**A, the first conductive member **21** may include a first notch portion **21**n and a first non-notch portion **21**u. For example, the direction from the first notch portion **21**n toward the first non-notch portion **21**u is along the first current path **21**cp including the first conductive member **21** and the first movable electrode **20**E.

A length Wn**1** of the first notch portion **21**n along a first cross direction Dx**1** perpendicular to the first current path **21**cp is less than a length Wu**1** of the first non-notch portion **21**u along the first cross direction Dx**1**. The first conductive member **21** easily breaks at the first notch portion **21**n.

For example, it is favorable for the first notch portion **21**n to be provided proximate to the first movable electrode **20**E. Thereby, the first notch portion **21**n breaks more easily when a portion of the first movable electrode **20**E contacts the first fixed electrode **11**. The distance between the first notch portion **21**n and the first movable electrode **20**E is short. For example, the distance between the first notch portion **21**n and the first movable electrode **20**E is not more than ½ of the first length of the first conductive member **21** along the first current path **21**cp including the first conductive member **21** and the first movable electrode **20**E (the sum of the lengths L**11** to L**17** of FIG. **4**A). The distance between the first notch portion **21**n and the first movable electrode **20**E may be not more than 1/10 of the first length. The distance between the first notch portion **21**n and the first movable electrode **20**E may be not more than 1/20 of the first length. The first conductive member **21** breaks more easily.

As shown in FIG. **6**B, the second conductive member **22** includes a second notch portion **22**n and a second non-notch portion **22**u. The direction from the second notch portion **22**n toward the second non-notch portion **22**u is along the second current path **22**cp including the second conductive member **22** and the first movable electrode **20**E. A length Wn**2** of the second notch portion **22**n along a second cross direction Dx**2** perpendicular to the second current path **22**cp is less than a length Wu**2** of the second non-notch portion **22**u along the second cross direction Dx**2**. The second conductive member **22** breaks more easily due to such a second notch portion **22**n.

FIG. **7**A and FIG. **7**B are schematic plan views illustrating a MEMS element according to the first embodiment.

These drawings illustrate a portion of the MEMS element **114** according to the embodiment. FIG. **7**A illustrates the first conductive member **21**. FIG. **7**B illustrates the second conductive member **22**.

As shown in FIG. **7**A, the first conductive member **21** includes the first notch portion **21**n and the first non-notch portion **21**u. The length Wn**1** of the first notch portion **21**n is less than the length Wu**1** of the first non-notch portion **21**u. In the MEMS element **114**, the first notch portion **21**n

overlaps the end portion **11**p of the first fixed electrode **11** in the first direction (the Z-axis direction), which is from the first fixed electrode **11** toward the first movable electrode **20**E. The first notch portion **21**n breaks more easily.

As shown in FIG. **7**B, the second conductive member **22** includes the second notch portion **22**n and the second non-notch portion **22**u. The length Wn**2** of the second notch portion **22**n is less than the length Wu**2** of the second non-notch portion **22**u. In the MEMS element **114**, the second notch portion **22**n overlaps an end portion **11**q of the first fixed electrode **11** in the first direction (the Z-axis direction), which is from the first fixed electrode **11** toward the first movable electrode **20**E. The second notch portion **22**n breaks more easily.

In the embodiment, the breakage of the first and second conductive members **21** and **22** is performed by, for example, a local temperature increase. In such a case, the compositions, etc., of these conductive members may change. Such examples will now be described.

FIG. **8**A to FIG. **8**C are schematic plan views illustrating the MEMS element according to the first embodiment.

In the second state ST**2** as shown in FIG. **8**A, the break portion **21**B of the first conductive member **21** is formed, and the break portion **22**B is formed in the second conductive member **22**. FIG. **8**B illustrates the break portion **21**B. FIG. **8**C illustrates the break portion **22**B.

In the second state ST**2** as shown in FIG. **8**B, the first conductive member **21** includes a first portion p**1** and a second portion p**2**. The distance between the break portion **21**B and the first portion p**1** of the first conductive member **21** is greater than the distance between the break portion **21**B and the second portion p**2** of the first conductive member **21**. The second portion p**2** is proximate to the break portion **21**B. The first portion p**1** is far from the break portion **21**B. For example, there are cases where the color or the like of the second portion p**2** is different from that of the first portion p**1** due to a high temperature, etc. For example, the second portion p**2** may have at least one of a different light reflectance from the light reflectance of the first portion p**1**, a different color from the color of the first portion p**1**, a different unevenness from the unevenness of the first portion p**1**, a different composition from the composition of the first portion p**1**, or a different oxygen concentration from the oxygen concentration included in the first portion p**1**. There are cases where differences occur between the first portion p**1** and the second portion p**2** such as those recited above when the break occurs due to the effects of heat, etc.

In the second state ST**2** as shown in FIG. **8**C, the second conductive member **22** includes a third portion p**3** and a fourth portion p**4**. The distance between the break portion **22**B and the third portion p**3** of the second conductive member **22** is greater than the distance between the break portion **22**B and the fourth portion p**4** of the second conductive member **22**. The fourth portion p**4** is proximate to the break portion **22**B. The third portion p**3** is far from the break portion **22**B. For example, the fourth portion p**4** may have at least one of a different light reflectance from the light reflectance of the third portion p**3**, a different color from the color of the third portion p**3**, a different unevenness from the unevenness of the third portion p**3**, a different composition from the composition of the third portion p**3**, or a different oxygen concentration from the oxygen concentration included in the third portion p**3**. There are cases where differences between the third portion p**3** and the fourth portion p**4** occur such as those recited above when the breakage occurs due to the effects of heat, etc.

FIG. **9** is a schematic cross-sectional view illustrating a MEMS element according to the first embodiment.

FIG. **9** illustrates the MEMS element **118** according to the embodiment. FIG. **9** illustrates the first state ST**1**. As shown in FIG. **9**, the MEMS element **118** further includes a second member **42** in addition to the element part **51**. The first fixed electrode **11** and the first movable electrode **20**E are between the first member **41** and the second member **42**. In the first state ST**1**, the first gap g**1** is between the first fixed electrode **11** and the first movable electrode **20**E. In the first state ST**1**, a second gap g**2** is between the first movable electrode **20**E and the second member **42**.

The second member **42** is, for example, a cap. The first movable electrode **20**E can be displaced along the Z-axis direction due to the first and second gaps g**1** and g**2**. For example, the first gap g**1** and the second gap g**2** may be in a reduced-pressure state. For example, an inert gas may be introduced to the first and second gaps g**1** and g**2**.

For example, the first member **41** may include a control circuit part **41**t. The control circuit part **41**t includes, for example, a switching element such as a transistor, etc. The application of the first electrical signal Sg**1** to the first fixed electrode **11** may be controlled by the control circuit part **41**t.

Second Embodiment

FIG. **10**A and FIG. **10**B are schematic views illustrating a MEMS element according to a second embodiment.

FIG. **10**A is a plan view as viewed along arrow AR**2** of FIG. **10**B. FIG. **10**B is a line B**1**-B**2** cross-sectional view of FIG. **10**A.

As shown in FIG. **10**B, the MEMS element **120** according to the embodiment also includes the first member **41** and the element part **51**. In the MEMS element **120**, the element part **51** includes a second fixed electrode **12** in addition to the first fixed electrode **11**, the first movable electrode **20**E, the first conductive member **21**, and the second conductive member **22**. The configurations of the first fixed electrode **11**, the first movable electrode **20**E, the first conductive member **21**, and the second conductive member **22** in the MEMS element **120** may be similar to these configurations in the first embodiment. The second fixed electrode **12** will now be described.

As shown in FIG. **10**B, the second fixed electrode **12** is fixed to the first member **41**. The first movable electrode **20**E includes a first electrode region **20**Ea and a second electrode region **20**Eb. The distance between the first electrode region **20**Ea and the first conductive member **21** is less than the distance between the second electrode region **20**Eb and the first conductive member **21**. The first electrode region **20**Ea is the region at the first conductive member **21** side. The second electrode region **20**Eb is the region at the second conductive member **22** side.

The first electrode region **20**Ea faces the first fixed electrode **11**. The second electrode region **20**Eb faces the second fixed electrode **12**.

For example, the controller **70** can be electrically connected to the first fixed electrode **11** via the first control terminal Tc**1**. The controller **70** can be electrically connected to the second fixed electrode **12** via a second control terminal Tc**2**. In the example, the controller **70** is electrically connected to the second conductive member **22** via the second terminal T**2**. For example, a second electrical signal Sg**2** can be applied between the second conductive member **22** and the second fixed electrode **12** by the controller **70**.

FIG. 10B corresponds to the first state ST1. The first state ST1 is the state before the second electrical signal Sg2 is applied between the second conductive member 22 and the second fixed electrode 12. In the first state ST1, the first conductive member 21 and the second conductive member 22 support the first movable electrode 20E to be separated from the second fixed electrode 12. In the first state ST1 as described above, the first conductive member 21 and the second conductive member 22 support the first movable electrode 20E to be separated from the first fixed electrode 11.

For example, the second state ST2 is the state after the second electrical signal Sg2 is applied between the second conductive member 22 and the second fixed electrode 12. As described below, in the second state ST2, the first conductive member 21 and the second conductive member 22 are in a broken state.

As described below, the first conductive member 21 and the second conductive member 22 can be broken more stably by providing the first fixed electrode 11 and the second fixed electrode 12 in the MEMS element 120. In the second embodiment as well, a MEMS element can be provided in which a stable operation is possible.

An example of the transition from the first state ST1 to the second state ST2 will now be described.

FIG. 11A to FIG. 11C, FIG. 12A and FIG. 12B are schematic cross-sectional views illustrating the MEMS element according to the second embodiment.

In the first state ST1 shown in FIG. 11A, for example, an electrical signal for control is not applied between the second conductive member 22 and the first fixed electrode 11 or between the second conductive member 22 and the second fixed electrode 12. For example, the second conductive member 22, the first fixed electrode 11, and the second fixed electrode 12 are in the floating state FLT. At this time, the first movable electrode 20E is separated from the first fixed electrode 11 and the second fixed electrode 12. In such a first state ST1, a current can flow between the first terminal T1 and the second terminal T2. In the first state ST1, the element part 51 is in the conducting state (the on-state).

As shown in FIG. 11B, for example, the second terminal T2 (the second conductive member 22) is set to the ground potential V0, and the first electrical signal Sg1 is applied to the first fixed electrode 11. At this time, for example, the second fixed electrode 12 is set to the ground potential V0. Thereby, the first electrode region 20Ea of the first movable electrode 20E contacts the first fixed electrode 11. At this time, a state can be formed in which the second electrode region 20Eb is separated from the second fixed electrode 12. The temperature of the first conductive member 21 at the vicinity of the end portion 20Ep of the first movable electrode 20E is easily increased locally thereby. For example, the rise of the temperature is due to Joule heat.

When the temperatures of the end portions 20Ep and 21*p* locally rise, the first conductive member 21 breaks, and the break portion 21B is formed as shown in FIG. 11B.

As shown in FIG. 11C, the broken first conductive member 21 may approach the state of FIG. 11A. For example, this is due to the restoring force due to the elasticity of the first conductive member 21. As shown in FIG. 11C, the end portion 20Ep of the first movable electrode 20E is separated from the first conductive member 21. Thus, the first conductive member 21 is divided.

For example, when a portion of the first conductive member 21 overlaps the first fixed electrode 11 in the Z-axis direction, the end portion 21*p* of the first conductive member 21 easily contacts the first fixed electrode 11 when the first movable electrode 20E approaches the first fixed electrode 11. A current locally flows between the end portion 21*p* and the first fixed electrode 11. The temperature of the end portion 21*p* easily rises locally. The first conductive member 21 breaks more stably.

As shown in FIG. 12A, for example, the second terminal T2 (the second conductive member 22) is set to the ground potential V0, and the second electrical signal Sg2 is applied to the second fixed electrode 12. At this time, for example, the first fixed electrode 11 is set to the floating state FLT or a high-impedance state Hi-Z. For example, a current does not flow between the first fixed electrode 11 and the second fixed electrode 12. The temperature of the second conductive member 22 rises, and the second conductive member 22 breaks. For example, the rise of the temperature is due to Joule heat. The second conductive member 22 is divided at the break portion 22B. The application of the second electrical signal Sg2 ends.

As shown in FIG. 12B, the broken second conductive member 22 may approach the state of FIG. 11A. For example, this is due to the restoring force due to the elasticity of the second conductive member 22. As shown in FIG. 12B, the end portion 20Eq of the first movable electrode 20E is separated from the second conductive member 22.

In the second state ST2 shown in FIG. 12B, for example, the second conductive member 22, the first fixed electrode 11, and the second fixed electrode 12 are in the floating state FLT. The broken states of the first and second conductive members 21 and 22 continue even after the application of the first electrical signal Sg1 and the second electrical signal Sg2 has ended. In the second state ST2, a current does not flow between the first terminal T1 and the second terminal T2. In the second state ST2, the element part 51 is in the nonconducting state (the off-state).

Thus, in the MEMS element 120 according to the embodiment, both the first conductive member 21 and the second conductive member 22 are in a broken state in the second state ST2. The current that flows between the first terminal T1 and the second terminal T2 can be stably blocked thereby.

FIG. 13 is a schematic cross-sectional view illustrating a MEMS element according to the second embodiment.

FIG. 13 illustrates the MEMS element 121 according to the embodiment. FIG. 13 illustrates the first state ST1. As shown in FIG. 13, the MEMS element 121 includes the first member 41, the second member 42, and the element part 51. The first fixed electrode 11, the second fixed electrode 12, and the first movable electrode 20E are between the first member 41 and the second member 42. In the first state ST1, the first gap g1 is between the first fixed electrode 11 and the first movable electrode 20E and between the second fixed electrode 12 and the first movable electrode 20E. In the first state ST1, the second gap g2 is between the first movable electrode 20E and the second member 42. The first movable electrode 20E can be displaced along the Z-axis direction due to the first and second gaps g1 and g2.

It is favorable for the electrical resistances of the first and second conductive members 21 and 22 in the first and second embodiments to be, for example, 10Ω or less. By setting the electrical resistance to be low, a signal that has a high frequency can be efficiently transmitted with low loss.

In the first and second embodiments, for example, at least one of the first conductive member 21 or the second conductive member 22 includes at least one selected from the group consisting of Al, Cu, Au, Ti, Pd, Pt, and W. A low resistance is obtained, and good transmission in the element part **51** is obtained.

FIG. **14**A and FIG. **14**B are schematic views illustrating a MEMS element according to the second embodiment.

FIG. **14**A is a plan view. FIG. **14**B is a perspective view.

As shown in FIG. **14**B, the MEMS element **122** according to the embodiment also includes the first member **41** and the element part **51**. In the MEMS element **122**, the element part **51** includes the first fixed electrode **11**, the first movable electrode **20**E, the second fixed electrode **12**, the first conductive member **21**, and the second conductive member **22**. The configurations of the first movable electrode **20**E and the supporters in the MEMS element **122** are different from the configurations of the first movable electrode **20**E and the supporters in the MEMS element **120**. An example of the configurations of the first movable electrode **20**E and the supporters in the MEMS element **122** will now be described.

In the MEMS element **122** as shown in FIG. **14**A and FIG. **14**B, the first movable electrode **20**E further includes a third electrode region **20**Ec in addition to the first electrode region **20**Ea and the second electrode region **20**Eb. The third electrode region **20**Ec is between the first electrode region **20**Ea and the second electrode region **20**Eb.

The element part **51** includes the first supporter **21**S, the second supporter **22**S, and a third supporter **23**S. The first supporter **21**S, the second supporter **22**S, and the third supporter **23**S are fixed to the first member **41**. The first supporter **21**S, the second supporter **22**S, and the third supporter **23**S are not illustrated in FIG. **14**B.

The first supporter **21**S supports at least a portion of the first conductive member **21** to be separated from the first member **41**. The second supporter **22**S supports at least a portion of the second conductive member **22** to be separated from the first member **41**. The third supporter **23**S supports at least a portion of the third electrode region **20**Ec to be separated from the first member **41**.

For example, the third electrode region **20**Ec may be a portion including the X-axis direction center of the first movable electrode **20**E. For example, the third electrode region **20**Ec is at the central portion between the first conductive member **21** and the second conductive member **22**. In the MEMS element **122**, at least a portion of the third electrode region **20**Ec is supported to be separated from the first member **41**. Thereby, for example, the distance between the second electrode region **20**Eb and the second fixed electrode **12** increases when the distance between the first electrode region **20**Ea and the first fixed electrode **11** decreases. Both the first conductive member **21** and the second conductive member **22** break more easily and more stably. Examples of operations of the MEMS element **122** are described below.

In the example, the first movable electrode **20**E includes a first extension region **28***a*. The first extension region **28***a* extends along an extension direction. The extension direction is along a surface **41***a* of the first member **41** and crosses the direction (in the example, the X-axis direction) from the first electrode region **20**Ea toward the second electrode region **20**Eb. In the example, the extension direction is the Y-axis direction.

A portion (e.g., an end) of the first extension region **28***a* is connected to the third electrode region **20**Ec. Another portion (e.g., another end) of the first extension region **28***a* is connected to the third supporter **23**S.

Thus, the third supporter **23**S may support at least a portion of the third electrode region **20**Ec via the first extension region **28***a* to be separated from the first member **41**.

In the example, the first movable electrode **20**E includes a second extension region **28***b*. The third electrode region **20**Ec is between the first extension region **28***a* and the second extension region **28***b* in the extension direction recited above (e.g., the Y-axis direction).

The element part **51** further includes a fourth supporter **24**S fixed to the first member **41**. A portion (e.g., an end) of the second extension region **28***b* is connected to the third electrode region **20**Ec. Another portion (e.g., another end) of the second extension region **28***b* is connected to the fourth supporter **24**S.

Thus, the fourth supporter **24**S may support at least a portion of the third electrode region **20**Ec via the second extension region **28***b* to be separated from the first member **41**.

For example, the third supporter **23**S and the fourth supporter **24**S may be electrically insulated from the first movable electrode **20**E. The first electrode region **20**Ea, the second electrode region **20**Eb, the third electrode region **20**Ec, the first extension region **28***a*, and the second extension region **28***b* may be a continuous conductive layer. For example, the first extension region **28***a* and the second extension region **28***b* may function as a torsion spring.

Examples of operations of the MEMS element **122** will now be described.

FIG. **15**A to FIG. **15**C and FIG. **16**A to FIG. **16**C are schematic cross-sectional views illustrating the MEMS element according to the second embodiment.

These drawings correspond to a line B**1**-B**2** cross section of FIG. **14**A.

In the first state ST**1** shown in FIG. **15**A, for example, the second conductive member **22**, the first fixed electrode **11**, and the second fixed electrode **12** are set to the floating state FLT or the ground potential V**0**. In the first state ST**1**, the element part **51** is in the conducting state (the on-state).

As shown in FIG. **15**B, for example, the second terminal T**2** (the second conductive member **22**) is set to the ground potential V**0**, and the first electrical signal Sg**1** is applied to the first fixed electrode **11**. The first electrode region **20**Ea contacts the first fixed electrode **11**. Because the third electrode region **20**Ec is supported via the first extension region **28***a* to be separated from the first member **41**, the distance between the second electrode region **20**Eb and the second fixed electrode **12** increases. The temperature of the first conductive member **21** at the vicinity of the end portion **20**Ep of the first movable electrode **20**E easily rises locally.

When the temperature of the end portion **20**Ep and the end portion **21***p* locally rises, the first conductive member **21** breaks and the break portion **21**B is formed as shown in FIG. **15**B.

As shown in FIG. **15**C, the broken first conductive member **21** may approach the state of FIG. **11**A due to the restoring force due to the elasticity of the first conductive member **21**.

As shown in FIG. **16**A, for example, the second terminal T**2** (the second conductive member **22**) is set to the ground potential V**0**, and the second electrical signal Sg**2** is applied to the second fixed electrode **12**. At this time, for example, the first fixed electrode **11** is set to the ground potential V**0** or the high-impedance state Hi-Z. The temperature of the second conductive member **22** rises, and the second conductive member **22** breaks. The second conductive member

22 is divided at the break portion 22B. The application of the second electrical signal Sg2 ends.

As shown in FIG. 16B, the broken second conductive member 22 may approach the state of FIG. 16A due to the restoring force due to the elasticity of the second conductive member 22.

In the second state ST2 shown in FIG. 16C, for example, the second conductive member 22, the first fixed electrode 11, and the second fixed electrode 12 are in the floating state FLT. In the second state ST2, the element part 51 is in the nonconducting state (the off-state).

In the MEMS element 122, both the first conductive member 21 and the second conductive member 22 break easily in the second state ST2. The current that flows between the first terminal T1 and the second terminal T2 can be stably blocked.

FIG. 17A and FIG. 17B are schematic cross-sectional views illustrating the MEMS element according to the embodiment. These drawings illustrate another operation of the MEMS element 122. These drawings illustrate an operation after the operation described in reference to FIG. 15A to FIG. 15C is performed.

As shown in FIG. 17A, for example, the second terminal T2 (the second conductive member 22) is set to the ground potential V0, and a third electrical signal Sg3 is applied to the first fixed electrode 11. For example, the absolute value of the third electrical signal Sg3 is greater than the absolute value of the first electrical signal Sg1. The second conductive member 22 is broken thereby. As shown in FIG. 17A, the broken second conductive member 22 may approach the state of FIG. 15C due to the restoring force due to the elasticity of the second conductive member 22.

In the second state ST2 shown in FIG. 17B, for example, the second conductive member 22, the first fixed electrode 11, and the second fixed electrode 12 are in the floating state FLT. In the second state ST2, the element part 51 is in the nonconducting state (the off-state).

The configuration in which at least a portion of the third electrode region 20Ec is supported to be separated from the first member 41 may be applied to a configuration in which the second fixed electrode 12 is not provided. For example, the third electrode region 20Ec, the first extension region 28*a*, the second extension region 28*b*, the third supporter 23S, the fourth supporter 24S, etc., described in reference to the MEMS element 122 (referring to FIG. 14A) may be provided in the MEMS element 110 illustrated in FIG. 1A and FIG. 18.

For example, in the MEMS element 110, the first movable electrode 20E may include the first electrode region 20Ea, the second electrode region 20Eb, and the third electrode region 20Ec (referring to FIG. 14A). The first electrode region 20Ea is between the first conductive member 21 and the second conductive member 22. The second electrode region 20Eb is between the first electrode region 20Ea and the second conductive member 22. The third electrode region 20Ec is between the first electrode region 20Ea and the second electrode region 20Eb. The element part 51 includes the first supporter 21S that is fixed to the first member 41, the second supporter 22S that is fixed to the first member 41, and the third supporter 23S that is fixed to the first member 41. The first supporter 21S supports at least a portion of the first conductive member 21 to be separated from the first member 41. The second supporter 22S supports at least a portion of the second conductive member 22 to be separated from the first member 41. The third supporter 23S supports at least a portion of the third electrode region 20Ec to be separated from the first member 41. More stable breakage is obtained. In such a case, for example, the operation described in reference to FIG. 15A to FIG. 15C, FIG. 16A and FIG. 16B may be performed. In the example, the surface area of the portion of the first electrode region 20Ea facing the first fixed electrode 11 may be greater than the surface area of the portion of the second electrode region 20Eb facing the first fixed electrode 11.

Third Embodiment

FIG. 18 is a schematic view illustrating a MEMS element according to a third embodiment.

As shown in FIG. 18, the MEMS element 130 according to the embodiment includes multiple element parts 51. For example, the multiple element parts 51 are connected in parallel. Control signals Vpp are applicable independently to the multiple element parts 51.

For example, the first and second conductive members 21 and 22 included in one of the multiple element parts 51 are breakable independently from the first and second conductive members 21 and 22 included in another one of the multiple element parts 51.

Multiple first capacitance elements 31 are provided in the example. One of the multiple first capacitance elements 31 is connected in series to one of the multiple element parts 51. The MEMS element 130 is a capacitance element array including the multiple element parts 51 and the multiple first capacitance elements 31. Several of the multiple element parts 51 can be set to the off-state. The electrical capacitance of the MEMS element 130 can be modified by setting several of the multiple element parts 51 to the off-state.

Fourth Embodiment

A fourth embodiment relates to an electrical circuit. FIG. 18 illustrates the configuration of the electrical circuit 210 according to the embodiment. As shown in FIG. 18, the electrical circuit 210 includes a MEMS element (e.g., the MEMS element 130) according to the first to third embodiments and an electrical element 55. The electrical element 55 is electrically connected to the MEMS element 130. The electrical element 55 includes at least one selected from the group consisting of a resistance, a capacitance element, an inductor element, a diode, and a transistor. The capacitance element included in the electrical element 55 may include a sensor. For example, the electrical element 55 may include a sensor element. For example, the electrical element 55 may include a capacitive sensor element.

In the electrical circuit 210, the MEMS element (e.g., the MEMS element 130) may include multiple element parts 51. The characteristics of the electrical circuit 210 are controllable by breaking the first and second conductive members 21 and 22 included in at least one of the multiple element parts 51.

For example, when the MEMS element 130 includes the first capacitance element 31, the electrical capacitance of the MEMS element 130 can be controlled by breaking the first and second conductive members 21 and 22 included in at least one of the multiple element parts 51. As a result, the characteristics of the electrical circuit 210 are controllable.

For example, the electrical circuit 210 may be used in a voltage-controlled oscillator (VCO). For example, the electrical circuit 210 may be used in an impedance matching circuit of a high frequency circuit such as an antenna, etc. For example, the electrical circuit 210 may be used in a passive RF tag. For example, the characteristics of the electrical circuit 210 can be appropriately adjusted by adjusting an electrical capacitance or an inductor of the electrical circuit **210**. For example, a voltage-controlled oscillator (VCO) that has stable characteristics is obtained. For example, stable characteristics are obtained in the impedance matching circuit of a high frequency circuit such as an antenna, etc. For example, a passive RF tag or the like that has stable characteristics is obtained.

FIG. **19** and FIG. **20** are schematic views illustrating control circuits used in the MEMS element according to the embodiment.

As shown in FIG. **19**, a control circuit **310** includes a voltage step-up circuit **321**, a logic circuit **322**, and a switching matrix **323**. A power supply voltage Vcc is supplied to the voltage step-up circuit **321**. The voltage step-up circuit **321** outputs a high voltage Vh to the switching matrix **323**. The switching matrix **323** outputs multiple control signals Vpp according to a signal **322***a* supplied from the logic circuit **322** to the switching matrix **323**. One of the multiple control signals Vpp is supplied to one of the multiple element parts **51**.

As shown in FIG. **20**, a control circuit **311** includes a control power supply **324**, the logic circuit **322**, and the switching matrix **323**. The control power supply **324** is, for example, a control voltage source or a control current source. The control power supply **324** outputs, to the switching matrix **323**, the high voltage Vh and a large current Ih. The switching matrix **323** outputs the multiple control signals Vpp according to the signal **322***a* supplied to the switching matrix **323** from the logic circuit **322**. One of the multiple control signals Vpp is supplied to one of the multiple element parts **51**. The switching matrix **323** may output multiple control currents Ipp. One of the multiple control currents Ipp is supplied to one of the multiple element parts **51**.

For example, at least a portion of the control circuits **310** and **311** is included in, for example, the controller **70**.

Examples of the first electrical signal Sg**1** supplied between the second conductive member **22** and the first fixed electrode **11** from the controller **70** will now be described.

FIG. **21**A and FIG. **21**B are schematic views illustrating an operation relating to the MEMS element according to the first embodiment.

These figures show one example of the first electrical signal Sg**1**. In these figures, the horizontal axis is the time tm. The vertical axis of FIG. **21**A is a voltage Va**1** of the first electrical signal Sg**1**. The vertical axis of FIG. **21**B is a current Ia**1** of the first electrical signal Sg**1**.

As shown in FIG. **21**A, the voltage Va**1** starts to increase at a first time t**1**. The voltage Va**1** reaches a first voltage V**1** after a second time t**2**. The first voltage V**1** is maintained through third and fourth times t**3** and t**4**, and the voltage Va**1** starts to increase at the fourth time t**4**. The voltage Va**1** becomes a second voltage V**2** after the fourth time t**4**. Subsequently, the voltage Va**1** is maintained at the second voltage V**2** from a fifth time t**5** to a sixth time t**6**. The voltage Va**1** starts to drop at the sixth time t**6**. The drop of the voltage Va**1** ends at a seventh time t**7**; for example, the voltage Va**1** becomes 0 volts. The absolute value of the first voltage V**1** is less than the absolute value of the second voltage V**2**.

As shown in FIG. **21**B, the current Ia**1** substantially does not flow between the first time t**1** and the second time t**2**. The current Ia**1** becomes a first current I**1** after the second time t**2**. The current Ia**1** is less than the first current I**1** from the third time t**3** to the fourth time t**4**. The current Ia**1** starts to rise at the fourth time t**4** and becomes a second current I**2**. The current Ia**1** starts to drop at the fifth time t**5**, and the current Ia**1** does not flow at the sixth time t**6**. The absolute value of the first current I**1** is less than the absolute value of the second current I**2**.

For example, the first movable electrode **20**E approaches the first fixed electrode **11** in the period from the first time t**1** to the second time t**2**. For example, a portion of the first movable electrode **20**E (e.g., a portion at the first conductive member **21** side) contacts the first fixed electrode **11** at the second time t**2**. Thereby, in the period from the second time t**2** to the third time t**3**, the current Ia**1** increases, and the current Ia**1** becomes the first current I**1**. For example, the first conductive member **21** breaks at the third time t**3**, and the current Ia**1** decreases. Subsequently, in the period from the fourth time t**4** to the fifth time t**5**, the second conductive member **22** side of the first movable electrode **20**E approaches the first fixed electrode **11**, and the current Ia**1** increases. The current Ia**1** becomes the second current I**2** when the first movable electrode **20**E contacts the first fixed electrode **11**. The second conductive member **22** breaks at the fifth time t**5**, and the current Ia**1** drops.

For example, the first conductive member **21** and the second conductive member **22** are broken by the voltage Va**1** and the current Ia**1** illustrated in FIG. **21**A and FIG. **21**B.

FIG. **22**A and FIG. **22**B are schematic views illustrating an operation relating to the MEMS element according to the first embodiment.

These figures show another first electrical signal Sg**1**. In these figures, the horizontal axis is the time tm. The vertical axis of FIG. **22**A is the voltage Va**1** of the first electrical signal Sg**1**. The vertical axis of FIG. **22**B is the current Ia**1** of the first electrical signal Sg**1**.

In the example shown in FIG. **22**A, the voltage Va**1** changes similarly to FIG. **21**A.

As shown in FIG. **22**B, a current substantially does not flow between the first time t**1** and the second time t**2**. The current Ia**1** becomes a current Icomp**1** after the second time t**2** in the period between the second time t**2** and an eighth time t**8**. The eighth time t**8** is between the second time t**2** and the third time t**3**. The current Ia**1** is the first current I**1** after the eighth time t**8** in the period between the eighth time t**8** and the third time t**3**. The current Ia**1** is less than the first current I**1** between the third time t**3** and the fourth time t**4**. The current Ia**1** starts to rise at the fourth time t**4** and reaches a current Icomp**2**. Subsequently, the current Ia**1** again starts to rise at a ninth time t**9** and reaches the second current I**2**. The ninth time t**9** is between the fourth time t**4** and the fifth time t**5**. The current Ia**1** starts to drop at the fifth time t**5**, and the current Ia**1** does not flow at the sixth time t**6**. The absolute value of the first current ii is less than the absolute value of the second current I**2**.

For example, the first movable electrode **20**E approaches the first fixed electrode **11** in the period from the first time t**1** to the second time t**2**. For example, a portion of the first movable electrode **20**E (e.g., a portion at the first conductive member **21** side) contacts the first fixed electrode **11** at the second time t**2**. The current Ia**1** increases to the current Icomp**1** at the second time t**2**. At the eighth time t**8** at which the current Ia**1** has reached the current Icomp**1**, the current Ia**1** that is supplied from the controller **70** is increased, and the current Ia**1** is set to the first current I**1**. For example, the first conductive member **21** breaks at the third time t**3**, and the current Ia**1** drops. Subsequently, the second conductive member **22** side of the first movable electrode **20**E starts to approach the first fixed electrode **11** at the fourth time t**4**, and the current Ia**1** increases. The first movable electrode **20**E contacts the first fixed electrode **11**, and the current Ia**1** increases to the current Icomp**2**. At the ninth time t**9** at which the current Ia**1** has reached the current Icomp**2**, the current Ia**1** that is supplied by the controller **70** is increased, and the current Ia**1** is set to the second current I**2**. At the fifth time t**5**, the second conductive member **22** breaks, and the current Ia**1** drops.

For example, the first conductive member **21** and the second conductive member **22** are broken by the voltage Va**1** and the current Ia**1** illustrated in FIG. **22**A and FIG. **22**B.

The embodiments may include the following configurations (e.g., technological proposals).

Configuration 1

A MEMS element, comprising:

a first member; and

an element part,

the element part including

a first fixed electrode fixed to the first member,

a first movable electrode facing the first fixed electrode,

a first conductive member electrically connected to the first movable electrode, and

a second conductive member electrically connected to the first movable electrode,

the first conductive member and the second conductive member supporting the first movable electrode to be separated from the first fixed electrode in a first state before a first electrical signal is applied between the second conductive member and the first fixed electrode,

the first conductive member and the second conductive member being in a broken state in a second state after the first electrical signal is applied between the second conductive member and the first fixed electrode.

Configuration 2

The MEMS element according to Configuration 1, wherein

a rigidity of the first conductive member is different from a rigidity of the second conductive member.

Configuration 3

The MEMS element according to Configuration 1 or 2, wherein

the first conductive member has a first length along a first current path, and a first width in a direction perpendicular to the first current path, the first current path including the first conductive member and the first movable electrode, and

the second conductive member has at least one of a second length along a second current path, or a second width in a direction perpendicular to the second current path, the second current path including the second conductive member and the first movable electrode, the second length being less than the first length, the second width being greater than the first width.

Configuration 4

The MEMS element according to any one of Configurations 1 to 3, wherein

at least one of a portion of the first conductive member or a portion of the second conductive member overlaps the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

Configuration 5

The MEMS element according to any one of Configurations 1 to 3, wherein

the first conductive member includes a first notch portion and a first non-notch portion, a direction from the first notch portion toward the first non-notch portion being along a first current path including the first conductive member and the first movable electrode, and

a length of the first notch portion along a first cross direction perpendicular to the first current path is less than a length of the first non-notch portion along the first cross direction.

Configuration 6

The MEMS element according to Configuration 5, wherein

a distance between the first notch portion and the first movable electrode is not more than ½ of a first length of the first conductive member along a first current path, the first current path including the first conductive member and the first movable electrode.

Configuration 7

The MEMS element according to Configuration 5 or 6, wherein

the first notch portion overlaps an end portion of the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

Configuration 8

The MEMS element according to any one of Configurations 5 to 7, wherein

the second conductive member includes a second notch portion and a second non-notch portion, a direction from the second notch portion toward the second non-notch portion being along a second current path including the second conductive member and the first movable electrode, and

a length of the second notch portion along a second cross direction perpendicular to the second current path is less than a length of the second non-notch portion along the second cross direction.

Configuration 9

The MEMS element according to any one of Configurations 1 to 3, wherein

the second conductive member includes a second notch portion and a second non-notch portion, a direction from the second notch portion toward the second non-notch portion being along a second current path including the second conductive member and the first movable electrode,

a length of the second notch portion along a second cross direction perpendicular to the second current path is less than a length of the second non-notch portion along the second cross direction, and

the second notch portion overlaps an end portion of the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

Configuration 10

The MEMS element according to any one of Configurations 1 to 9, further comprising:

a second member,

the first fixed electrode and the first movable electrode being between the first member and the second member,

a first gap being between the first fixed electrode and the first movable electrode in the first state,

a second gap being between the first movable electrode and the second member in the first state.

Configuration 11

The MEMS element according to any one of Configurations 1 to 10, wherein

a current can flow between the first movable electrode and the first fixed electrode when the first electrical signal is applied between the second conductive member and the first fixed electrode.

Configuration 12

The MEMS element according to any one of Configurations 1 to 11, wherein the first movable electrode contacts the first fixed electrode when the first electrical signal is applied between the second conductive member and the first fixed electrode.

Configuration 13

The MEMS element according to any one of Configurations 1 to 12, wherein

the element part further includes a first capacitance element electrically connected to the first conductive member.

Configuration 14

The MEMS element according to any one of Configurations 1 to 13, wherein

the element part further includes a second fixed electrode fixed to the first member,

the first movable electrode includes a first electrode region and a second electrode region,

a distance between the first electrode region and the first conductive member is less than a distance between the second electrode region and the first conductive member,

the first electrode region faces the first fixed electrode,

the second electrode region faces the second fixed electrode,

the first state is before a second electrical signal is applied between the second conductive member and the second fixed electrode,

the first conductive member and the second conductive member support the first movable electrode to be separated from the second fixed electrode in the first state,

the second state is after the second electrical signal is applied between the second conductive member and the second fixed electrode, and

the first conductive member and the second conductive member are in a broken state in the second state.

Configuration 15

The MEMS element according to Configuration 14, wherein

a start of an application of the second electrical signal is after a start of an application of the first electrical signal.

Configuration 16

The MEMS element according to Configuration 15, wherein

an end of the application of the second electrical signal is after an end of the application of the first electrical signal.

Configuration 17

The MEMS element according to any one of Configurations 14 to 16, wherein

the first movable electrode further includes a third electrode region between the first electrode region and the second electrode region,

the element part includes a first supporter fixed to the first member, a second supporter fixed to the first member, and a third supporter fixed to the first member,

the first supporter supports at least a portion of the first conductive member to be separated from the first member,

the second supporter supports at least a portion of the second conductive member to be separated from the first member, and

the third supporter supports at least a portion of the third electrode region to be separated from the first member.

Configuration 18

The MEMS element according to any one of Configurations 1 to 13, wherein

the first movable electrode includes a first electrode region, a second electrode region, and a third electrode region, the first electrode region being between the first conductive member and the second conductive member, the second electrode region being between the first electrode region and the second conductive member, the third electrode region being between the first electrode region and the second electrode region,

the element part includes a first supporter fixed to the first member, a second supporter fixed to the first member, and a third supporter fixed to the first member,

the first supporter supports at least a portion of the first conductive member to be separated from the first member,

the second supporter supports at least a portion of the second conductive member to be separated from the first member, and

the third supporter supports at least a portion of the third electrode region to be separated from the first member.

Configuration 19

The MEMS element according to Configuration 17 or 18, wherein

the first movable electrode includes a first extension region,

the first extension region extends along an extension direction,

the extension direction is along a surface of the first member and crosses a direction from the first electrode region toward the second electrode region,

a portion of the first extension region is connected to the third electrode region, and

an other portion of the first extension region is connected to the third supporter.

Configuration 20

The MEMS element according to Configuration 19, wherein

the first movable electrode includes a second extension region,

the third electrode region is between the first extension region and the second extension region in the extension direction,

the element part further includes a fourth supporter fixed to the first member,

a portion of the second extension region is connected to the third electrode region, and

an other portion of the second extension region is connected to the fourth supporter.

Configuration 21

The MEMS element according to any one of Configurations 1 to 20, wherein

at least one of the first conductive member or the second conductive member includes at least one selected from the group consisting of Al, Cu, Au, Ti, Pd, Pt, and W.

Configuration 22

The MEMS element according to any one of Configurations 1 to 21, comprising:

a plurality of the element parts,

the first and second conductive members included in one of the plurality of element parts being breakable independently from the first and second conductive members included in an other one of the plurality of element parts.

Configuration 23

An electrical circuit, comprising:

the MEMS element according to any one of Configurations 1 to 22; and

an electrical element electrically connected to the MEMS element,

the electrical element including at least one selected from the group consisting of a resistance, a capacitance element, an inductor element, a diode, and a transistor.

Configuration 24

An electrical circuit, comprising:

the MEMS element according to any one of Configurations 1 to 22; and

an electrical element electrically connected to the MEMS element,

the electrical element including a sensor element.

Configuration 25

The electrical circuit according to Configuration 23 or 24, wherein

the MEMS element includes a plurality of the element parts, and

a characteristic of the electrical circuit is controllable by breaking the first and second conductive members included in at least one of the plurality of element parts.

According to the embodiments, a MEMS element and an electrical circuit can be provided in which a stable operation is possible.

Hereinabove, exemplary embodiments of the invention are described with reference to specific examples. However, the embodiments of the invention are not limited to these specific examples. For example, one skilled in the art may similarly practice the invention by appropriately selecting specific configurations of components included in MEMS elements and electrical circuits such as first members, element parts, fixed electrodes, movable electrodes, first conductive members, second conductive members, etc., from known art. Such practice is included in the scope of the invention to the extent that similar effects thereto are obtained.

Further, any two or more components of the specific examples may be combined within the extent of technical feasibility and are included in the scope of the invention to the extent that the purport of the invention is included.

Moreover, all MEMS elements, and electrical circuits practicable by an appropriate design modification by one skilled in the art based on the MEMS members, and the electrical circuits described above as embodiments of the invention also are within the scope of the invention to the extent that the purport of the invention is included.

Various other variations and modifications can be conceived by those skilled in the art within the spirit of the invention, and it is understood that such variations and modifications are also encompassed within the scope of the invention.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

What is claimed is:

1. A MEMS element, comprising:

a first member; and

an element part,

the element part including

a first fixed electrode fixed to the first member,

a first movable electrode facing the first fixed electrode,

a first conductive member electrically connected to the first movable electrode, and

a second conductive member electrically connected to the first movable electrode,

the first conductive member and the second conductive member supporting the first movable electrode to be separated from the first fixed electrode in a first state before a first electrical signal is applied between the second conductive member and the first fixed electrode,

the first conductive member and the second conductive member being in a broken state in a second state after the first electrical signal is applied between the second conductive member and the first fixed electrode.

2. The element according to claim **1**, wherein

a rigidity of the first conductive member is different from a rigidity of the second conductive member.

3. The element according to claim **1**, wherein

the first conductive member has a first length along a first current path, and a first width in a direction perpendicular to the first current path, the first current path including the first conductive member and the first movable electrode, and

the second conductive member has at least one of a second length along a second current path, or a second width in a direction perpendicular to the second current path, the second current path including the second conductive member and the first movable electrode, the second length being less than the first length, the second width being greater than the first width.

4. The element according to claim **1**, wherein

at least one of a portion of the first conductive member or a portion of the second conductive member overlaps the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

5. The element according to claim **1**, wherein

the second conductive member includes a second notch portion and a second non-notch portion, a direction from the second notch portion toward the second non-notch portion being along a second current path including the second conductive member and the first movable electrode,

a length of the second notch portion along a second cross direction perpendicular to the second current path is less than a length of the second non-notch portion along the second cross direction, and

the second notch portion overlaps an end portion of the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

6. The element according to claim **1**, further comprising:

a second member,

the first fixed electrode and the first movable electrode being between the first member and the second member,

a first gap being between the first fixed electrode and the first movable electrode in the first state,

a second gap being between the first movable electrode and the second member in the first state.

7. The element according to claim **1**, wherein

a current can flow between the first movable electrode and the first fixed electrode when the first electrical signal is applied between the second conductive member and the first fixed electrode.

8. The element according to claim **1**, wherein

the first movable electrode contacts the first fixed electrode when the first electrical signal is applied between the second conductive member and the first fixed electrode.

9. The element according to claim **1**, wherein

the element part further includes a first capacitance element electrically connected to the first conductive member.

10. The element according to claim 1, wherein
the first movable electrode includes a first electrode region, a second electrode region, and a third electrode region, the first electrode region being between the first conductive member and the second conductive member, the second electrode region being between the first electrode region and the second conductive member, the third electrode region being between the first electrode region and the second electrode region,
the element part includes a first supporter fixed to the first member, a second supporter fixed to the first member, and a third supporter fixed to the first member,
the first supporter supports at least a portion of the first conductive member to be separated from the first member,
the second supporter supports at least a portion of the second conductive member to be separated from the first member, and
the third supporter supports at least a portion of the third electrode region to be separated from the first member.

11. An electrical circuit, comprising:
the MEMS element according to claim 1; and
an electrical element electrically connected to the MEMS element,
the electrical element including at least one selected from the group consisting of a resistance, a capacitance element, an inductor element, a diode, and a transistor.

12. The element according to claim 1, wherein
the first conductive member includes a first notch portion and a first non-notch portion, a direction from the first notch portion toward the first non-notch portion being along a first current path including the first conductive member and the first movable electrode, and
a length of the first notch portion along a first cross direction perpendicular to the first current path is less than a length of the first non-notch portion along the first cross direction.

13. The element according to claim 12, wherein
a distance between the first notch portion and the first movable electrode is not more than ½ of a first length of the first conductive member along a first current path, the first current path including the first conductive member and the first movable electrode.

14. The element according to claim 12, wherein
the first notch portion overlaps an end portion of the first fixed electrode in a first direction from the first fixed electrode toward the first movable electrode.

15. The element according to claim 12, wherein
the second conductive member includes a second notch portion and a second non-notch portion, a direction from the second notch portion toward the second non-notch portion being along a second current path including the second conductive member and the first movable electrode, and
a length of the second notch portion along a second cross direction perpendicular to the second current path is less than a length of the second non-notch portion along the second cross direction.

16. The element according to claim 1, wherein
the element part further includes a second fixed electrode fixed to the first member,
the first movable electrode includes a first electrode region and a second electrode region,
a distance between the first electrode region and the first conductive member is less than a distance between the second electrode region and the first conductive member,
the first electrode region faces the first fixed electrode,
the second electrode region faces the second fixed electrode,
the first state is before a second electrical signal is applied between the second conductive member and the second fixed electrode,
the first conductive member and the second conductive member support the first movable electrode to be separated from the second fixed electrode in the first state,
the second state is after the second electrical signal is applied between the second conductive member and the second fixed electrode, and
the first conductive member and the second conductive member are in the broken state in the second state.

17. The element according to claim 16, wherein
a start of an application of the second electrical signal is after a start of an application of the first electrical signal.

18. The MEMS element according to claim 17, wherein
an end of the application of the second electrical signal is after an end of the application of the first electrical signal.

19. The element according to claim 16, wherein
the first movable electrode further includes a third electrode region between the first electrode region and the second electrode region,
the element part includes a first supporter fixed to the first member, a second supporter fixed to the first member, and a third supporter fixed to the first member,
the first supporter supports at least a portion of the first conductive member to be separated from the first member,
the second supporter supports at least a portion of the second conductive member to be separated from the first member, and
the third supporter supports at least a portion of the third electrode region to be separated from the first member.

20. The element according to claim 19, wherein
the first movable electrode includes a first extension region,
the first extension region extends along an extension direction,
the extension direction is along a surface of the first member and crosses a direction from the first electrode region toward the second electrode region,
a portion of the first extension region is connected to the third electrode region, and
an other portion of the first extension region is connected to the third supporter.

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